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INDUSTRIAL QUALITY CONTROL

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Management Planning and Control for an Effective Quality Function

QUALITY through Scientific Methods

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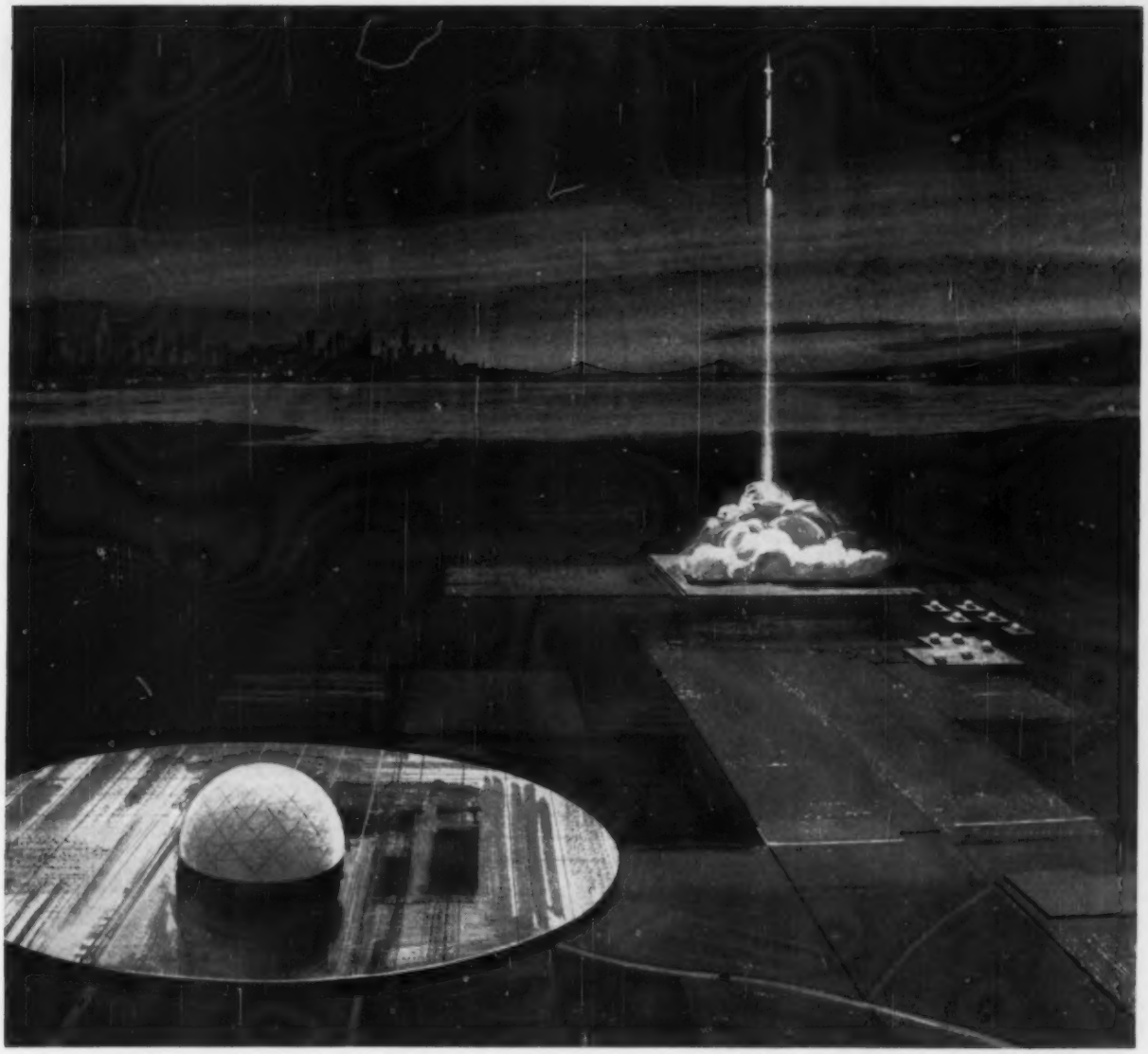

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RELIABILITY

Where Do We Go from Here?

JAMES N. DAVIS

Deputy Assistant Secretary of Defense for Production Management, Washington, D.C.

RELIABILITY, as a subject, appears at times to be a kind of disembodied spirit—difficult for the industry-government leadership to relate to the practical considerations of manufacturing and Defense procurement. Failure of military equipment, the inverse expression of reliability, has been watched in a non-statistical way for decades, and ordnance items became subject to systematic control years ago. Today, reliability, without the word actually being used, has become of great social importance as our missile and our space activities become matters of national and international interest. The score-keeping on launchings which is conspicious in the press is the popular expression of all the cumulative disciplines of manufacturing, testing and operations applied to insure success in performance.

More than ten years ago, I was first drawn into this field as a member of a small group appointed within the framework of the former Research and Development Board, to develop a formula which would predict the mean-time-to-failure of electronic equipment built to the standards of the day. Early work, such as this, led to creation of the Advisory Group on Electronics Equipment in 1952. Cost of maintenance and failure rates were matters of growing concern, particularly in electronics. From those years to the present, few of us have been able to overlook the need for coming to grips with the underlying statistics and discipline which have such a dramatic effect on the assurance that our man-machine systems in Defense will function predictably and successfully. The existence of this Society with its impressive membership, concerning itself professionally with the translation of reliability as an abstraction into design, production and testing actions, is the best measure of our national concern and the vigor of industry's response. I can report, and many of you have witnessed in recent years, an increasing effort to collect and analyze data from field experience — whether it be on the performance of rifles, trucks, tanks on off-road marches, electronic equipment or our complex aircraft and missile systems, all in a search for clues to design or manufacturing or operational deficiencies which could be corrected to improve reliability.

ASQC LCS Code 000:00:000

Address at the Annual Banquet of ASQC, June 6, 1961, Philadelphia, Pa.

Progress and Problems in Reliability

What can be done to accelerate progress in reliability? Attacking fundamental problems first, we must improve the building blocks that go into the bigger things we buy. To improve these building blocks we first must develop and apply improved procedures for delineating clearly what the buyer expects and what the seller is obligated to deliver. This means that both in industry and Government, all of us must pay more attention to specifications. This may be our greatest opportunity.

IT MIGHT BE USEFUL to report on Government activities intended to strengthen the assurance of predictable performance and to comment on work which lies before us.

One trend now well underway in industry is to restate reliability in numerical terms. It is surprising to return from years in industry and find that Defense and military service regulations guiding the procurement of components are not abreast of the available quality control art in delineating numerically the practices needed to demonstrate levels of assurance that components will perform as predicted, so that they can be purchased on this basis.

Reliability System Organization

There are perhaps 25 Service documents dealing with systems reliability, some of them divergent from others and perhaps confusing to industry. You may expect some consolidation of these and revision in the future. Those which I have read seem to concern themselves with who is responsible for reliability, a requirement that industry establish an identifiable internal group within a company which will be active, and lastly the philosophical importance of reliability. We now need to come to grips with the problem in a more definitive manner—and this is intricate, requiring the closest cooperation between industry and Government. Assuredly, within a company, there needs to be a nucleus of professional people skilled at bridging the gap between the mathematics underlying reliability and the design and fabrication processes. Recently, I visited a very large concern and listened to an executive describe his staff. He explained that he had 310 physicists, 512 chemists, and 4,000 engineers. At this point he paused and then remarked, "Sometimes I wonder whether we solve problems. I think we often just trample them to death." Thus he very effectively communicated to me his problem of communications.

A monitorship of the impact of design and process changes on end-product reliability is a very valuable guide to technical and management decisions. In my experience there is a danger in the aloofness of the auditing attitude that can erect barriers and slow down the adjustment of industrial processes which are needed to increase product reliability. It is management's responsibility to insure the closest working relationship between quality control, engineering and design in spite of the spirited discussions between these groups which tend to obscure their common goal. I know of one General Officer, responsible for results in space launchings, who periodically convenes the top executive from each of the major producers on one of his programs to review the status of their products. This has the excellent effect of encouraging the top man to school himself on technical, production and quality problems so that he can answer questions, and thereafter pay close attention to the workings of his company which bear on the quality of its product.

NOW that we have the boss fully attentive to reliability, this is an appropriate time to mention the subject of communication. Reliability is enmeshed in a highly sophisticated statistical-engineering language. This creates difficulties in communication. Probably this semantic sophistication is unavoidable in view of the complexity of the problems. In any event, a reliability staff is obligated to transmit clearly its viewpoint to Design and Production people. It must also reflect accurately management's contractual obligations. Probably the best that can said is that:

> Reliability specialists, whether staff or line, would be well advised not to allow the subtleties of their professional language, nor trappings of their professional identification, to become walls that entrap and isolate them within the larger industrial community.

In the past decade, then, the organization within a company of persons responsible for reliability has been called out in Government directives. It is now important to accent the actions which must be taken to assure a reliable product. Industry and Government together should begin to lay emphasis on the function rather than organization. You may expect in the future that military systems specifications for reliability will underscore action rather than organization. It is best to let each company devise its own organization, assign the responsibility and the monitorship of the results.

Darnell Report Implementation

The *Ad Hoc* Group on Part Specification Management, chaired by Paul S. Darnell, published its report last year. Subsequently, a Defense-wide task group was established to prepare a work plan implementing the Darnell Recommendations. This group established 14 tasks responding to the technical recommendations of the Report and three tasks bearing on organization recommendations. The technical tasks relate to introducing quantitative methodology into parts specifications; revision of qualification approval procedures in the Standardization Manual, M-200 as well as changes in documentation, specification practices, inspection and part-numbering practices. This is all underway. Other tasks include the development of techniques, tests and reliability doctrine for small lots; and development of a manual as guidance for inclusion of qualified reliability performance factors in parts specifications. A draft of this manual is completed and is being reviewed by Service groups. A task to establish a program to train inspectors to use new life test sampling procedures and acceptance criteria will soon be initiated now that the manual is in being. In organizational matters, the Darnell report recommended a central DoD group to support standardization actions on electronic parts. Actions bearing on this are still pending and we are hopeful of a clear plan of action soon. The charter for this group has been coordinated and is being drafted as a DoD directive.

Thus I have tried to summarize the principal activity in Defense, responsive to the Darnell Report.

LET US TURN for a moment to the problems we face today and in the future. We are engaged more and more in the limited production of extremely expensive and intricate end-items which are expended upon initial use. Perhaps a better understanding and application of small sample theory is needed. The answer is not bigger investments in more destructive testing. To demonstrate with 90 percent confidence that a particular missile system exceeds a reliability of 80 percent would require ten successes in ten firings, or 17 out of 18, or 23 out of 25. When the item is inexpensive the approach is more satisfactory. I know of one company which consumes a sample of 95 spin rockets in establishing the reliability of the last five in a lot of 100.

Improved Manufacturing Controls

In view of the limitations of statistical sampling methods, we can expect that manufacturing controls will become much more severe. The mere fact that fabrication or manufacturing is considered developmental does not minimize the necessity for meticulous control of manufacturing. Many of us have experienced the situation in which a developmental model performed satisfactorily and subsequent models were substantially less than satisfactory. This, to me, indicates the importance of exacting control of fabrication—in minute detail, at all times, and under all circumstances—regardless of whether we are speaking of research, development or production.

I would predict a growing use of physicists and chemists specializing in processing to support design and manufacture. These people are trained to ask "why" events take place, although in some industries they have been relegated to testing laboratories. Fortunately the realization is spreading that electrochemistry of metals, flow and memory of plastics, residual impurities in cleaning and processing can create second and third order problems which may escape the engineering designer. A stable solution of quality control rejection of parts may not be found in doubling the tooling and production in order to select a few good parts from many. A less costly and wasteful approach may be to apply men with basic science disciplines to the problem—and applying them before the pressure of deliveries leads to emergency measures.

Reducing Human Errors

The use of statistical controls in testing can reasonably well predict for us the final performance of a series of sub-systems or complete advanced systems such as missiles. It does not impose effectively the necessary disciplines on the people who fabricate, maintain and operate these large systems. Defects of training are becoming less tolerable as inherent in human behavior. The price of human error

comes too high. The number of quality control people and guardians of our hardware are gradually increasing. Perhaps this is an effective trend. However, it must be augmented by a constant campaign to alert all persons to use care in handling and working on critical parts. In one company a finished part is locked up and is not touched without a form being filled out describing just how it is to be treated, and two men taking the action together. Constant attention is needed to keep the untrained mind from placing an untrained hand on high-reliability mechanisms. One organization finds that 65 percent of the difficulties on the launching pad are attributed to human errors on location. This illustrates how we are faced with the problems of carefully training teams of men to perform intricate functions accurately. The Government recognizes it faces this problem as well as industry. New approaches to this problem of reducing human errors are needed. Greater freedom in exchange of ideas between industrial units and the Government are welcomed, in our continuing search for effective methods. Your Society may well be the group which should sponsor tours, symposia or other actions which will cross-fertilize within Defense industry the exchange of ideas promoting reliable processing and handling procedures.

OTHER TOOLS of reliability and quality control activities coming in the near future are worthy of mention. For example, a growing awareness in Government of the importance of calibration of measuring and testing equipment. We are making confidence firings of some rocket engines which cost $100,000 per test. It therefore becomes very important that there be no question as to the performance of the measuring system, if costs are to be controlled. Existing statistical techniques applicable to calibration need translation into usable guides which illustrate how they are applied to practical situations. We are searching now for industrial or other professional talent who can help in this field. Sampling procedures and tables for reliability testing based on models which fit the failure rate peculiar to different mechanisms are being developed. Departure from the familiar exponential distribution of failure is exhibited by semi-conductors, ball bearings and other mechanisms. The work done at Cornell on the Weibull distribution under sponsorship by the Office of Naval Research will soon be published in a manual similar to H-108, issued recently by the Department of Defense. Thus statistical theory is translated into usable tools for industry.

Economic Aspects of Reliability

Let us review for a moment the economics of reliability. At present the Department of Defense is spending billions of dollars in missile and space programs. All of these programs involve substantial expenditures for reliability. In one program, for example, the DoD is spending approximately 16 million dollars per year solely for reliability. In another program, reliability represents a 12 million dollar a year investment for what is called special effort in reliability. A third program involves a relatively modest 6 million dollars or so. Keep in mind that these expenditures are in addition to normal costs for research, engineering and production and none of these, I understand, include the cost of confidence firings of complete items.

This brings up, of course, the interesting question as to why reliability is treated as a separate subject in contracting. Unquestionably there are many instances where costs can reasonably be funded as chargeable to reliability. In general, however, it might be to the advantage of both Government and industry if we treated reliability as an inherent parameter of product or systems, not as something special.

After all, reliability is not something new. When we purchase even a comparatively simple mechanism such as a pump we expect defect-free performance for a reasonable period of time. We do not buy pumps and reliability separately.

Of course, costs must be borne and it does no good to preach about high costs. At the same time there are actions which can be taken that both directly and indirectly help to restrain these costs. As I mentioned earlier with respect to components, the most effective thing that can be done by both Government and industry is to develop and apply techniques by which the reliability requirements are spelled out in a way that leaves no room for misunderstanding between vendors and customers. The Government is obligated to illustrate and to demonstrate with examples compliance to such requirements. Development of such documents must be done carefully, with the assistance of industry to insure realism and usefulness. Once done, we may expect that future vendor-Government relations will be characterized by contracts which specify reliability requirements in engineering terms, and which relate reward and penalties to compliance with these requirements. In this way we can cut the costs of unreliability. These costs are substantial. At a conference last winter, Rear Admiral J. M. Lyle of the Naval Aviation Supply Office drove home this point of high cost with a few illustrations. Let me quote him:

> Here are a few examples of what material unreliability can do to us in the aviation supply business.
>
> A Horizon Stabilizer Actuator for one of our attack aircraft is an example of unreliability evidenced by failure or wear rate far exceeding that expected. The replacement rate which finally developed was 60 percent as contrasted with an expectation of 8 percent. Interpreted into dollars, this usage increase cost us four hundred thousand dollars additional in stock level buys. Moreover, this usage increase multiplied our repair and transportation costs seven times. To date, we have also encountered a ten months delay in developing full support capability.
>
> Or take a fuel control having current fighter application. The item costs us over $5,000. There have been 27 modifications to this control. Just bits and pieces to effect these modifications have cost us a total of two and one-half million dollars. The delays and other direct and indirect costs are not included.

He said further:

> We bought a Gas Turbine Compressor for twenty-one thousand dollars each. Engineering-wise, it wasn't up to fleet operational needs. One set of modifications cost us two million dollars for kits. Another series has now been issued which will cost us another three million dollars for kits. About one-half million dollars worth of ASO's systems parts will be made obsolete.

Summary

In closing it might be well to summarize, since we have touched on several problems bearing on

internal industrial activities and industry-Government relations.

Looking at the past ten or twelve years, one can view optimistically the trend toward increasing attention of higher echelons of leadership to the problems and cost of increasing reliability of Defense systems.

This trend is moving likewise in the direction of quantified requirements as a part of specifications, although we may not be satisfied with the rate of progress. More attention can be expected on quantifying specifications for both components and systems bearing on reliability in order to improve the understanding between industry and Government, to clarify our mutual objectives and to insure that the cost of reliability is applied rationally to the problem. Specifically, the Darnell Report has been a milestone, and we in the Government must convert its recommendations to actions beneficial to our industry-Government relationship.

Government can help stimulate top management's interest and attention in quality control, reliability and training of personnel, and should continue to do so. The interest in reduction of failure rates is of mutual interest and indistinguishable between Government and industry.

Process control, training of workers at all levels who participate in the handling and fabrication of high-reliability parts is needed, and we are seeking ways to encourage it.

Accelerated action is needed to translate statistical theory into usable tools for planning and executing reliability tests.

It can be stated clearly that the Secretary of Defense desires that the statement of work as exemplified by the specifications and the content of contracts be clarified so that industry-Government understanding of the task at hand be improved and that unnecessary costs be eliminated.

As Mr. McNamara recently said, we must enhance the capability of the U.S. to deter and defend itself against the risk of future wars and we must do this with a minimum increase in the cost of national defense. Your Society is playing, and I am sure will continue to play, a central role in realizing our national objective of applying technical progress to national defense at a price that does not impair the health of our economy.

Raising Productivity of INDIAN INDUSTRY Through Quality Control

WILLIAM R. PABST, JR.

Chief Statistician, Bureau of Naval Weapons, Navy Department

Formerly Advisor to the Government of India Under the United Nations Technical Assistance Program

INDIA, with its new and developing industries and with its national plans to raise the standard of living, presents a most interesting workshop for the effective utilization of SQC methods. It will be shown that these SQC techniques, when applied in the light of their effectiveness for the enterprise as a whole and for entire industries, that is in a "macro" approach, can be one of the most useful techniques in helping to increase productivity in the underdeveloped economies. Previous estimates that the productivity of Indian industry might be increased by as much as 20 percent through SQC are confirmed in the present project with the finding that productivity gains from ten to 40 percent are potentially available. This experience arises from a United Nations technical assistance program in quality control established in 1958-59 under the auspices of the Indian Statistical Institute.

Background

Statistical quality control has been known in India for a long time through the work of Professor P. C. Mahalanobis, Director of the Indian Statistical Institute, and his associates. In the late Forties, Professor Mahalanobis invited Walter Shewhart to India for a series of lectures on Quality Control. Subsequently the Indian Society for Quality Control (ISQC) was founded. In 1952-53, Ellis Ott led a team of four experts, including Paul Clifford, Anders Hald, and Mason Wescott, on a three month United Nations training assignment, giving four two-week SQC training courses in the principal cities. Upon the basis of the interest and enthusiasm developed, the Government—through the Indian Statistical Institute — established SQC Units[1] in Bombay, Calcutta, Bangalore and New Delhi, and later in Coimbatore and Baroda. These Units were established to service industry on a fee basis.

ASQC LCS Codes 310;320;330:10;20;60;70:400

Presented on the program of the ASQC Annual Convention, San Francisco, Calif., May, 1960

Present Situation

Today quality control is being used to an increasing extent in

many of the major industries throughout the country — in the production of shoes, sewing machines, fans, cotton and jute products, castings, telephones, textile machinery, railway cars, pharmaceuticals, cigarettes, plywood, biscuits, bicycles, and radios—among many other items. These recent applications of quality control methods have much in common, for they start with the search for those problem areas where statistical methodology can give the greatest returns; usually with the evaluation of outgoing product quality, the source of unusual scrap, or differential levels of efficiency.

From these strategic entry points, the minimum web of control spreads where it is needed through the production process, sometimes to the control of raw materials, the improvement of manual processing, the elimination of inefficient or defective machinery and equipment, to the imposition of standards for production and inspection, or to other areas where management must exercise remedial or corrective action. This is called a "macro" approach to distinguish it from one emphasizing methodology. This "macro" approach is based on the notion that these tools of quality control must be utilized by management, for management, in the economic interest of the company as a whole, if they are to be utilized effectively.

Statistical techniques alone do not provide all the answers to successful operation. They do, however, provide management with the communication network on the technical side necessary for wise administration. The quality techniques found most useful in the Indian industries do not attempt single-handedly to solve tough problems or to apply genius methods where others have failed. They simply provide the mechanism of focusing management attention on previously hidden obstacles, and of utilizing the usually competent existing technical staff where solution is necessary.

An Example: This approach is exemplified by the experience of a large plant in Calcutta producing sewing machines primarily for the domestic market in India and also for export to Egypt and Great Britain. It employs over four thousand workers and has a very competent technical staff. Attempts to use some of the tools of quality control over a period of time had been relatively unsuccessful because the control charts were not understood or were disregarded in the machine shop and assembly lines, and because successes in specific problem areas did not automatically spread. Besides, a sewing machine is assembled from more than five hundred parts and it was clearly impossible with limited staff to utilize control charts for every dimension of every one of these parts.

When a broader view of quality control methods was taken, the initial step showed that no measure of outgoing quality was easily available. The corps of skilled final inspectors had no definite criteria of performance; instead they varied in judgment very widely; for instance, over an entire month, one inspector rejected over forty percent of the machines coming to him; whereas another inspector dealing with the same flow of product rejected less than ten percent. Thereupon standards were developed utilizing the long time experience of operators for establishing procedural check-off lists

16th Midwest Conference Adopts "Universality of Statistics" Theme

Outstanding quality control experts and statisticians from a wide range of industries, universities and military installations will address the nearly 500 persons attending the 16th Midwest Conference, ASQC, Oct. 19-20, at the Chase-Park Plaza Hotel, St. Louis, Mo.

Speakers on subjects ranging from "Statistics and Sex" and "Statistics and the Stock Market," through "Effective Installation of Quality Control," will develop the theme of the Conference, "The Universality of Statistics."

Conference topics and speakers include:

"The Art of Listening," the opening address, by Dr. Ralph G. Nichols, head of the Rhetoric Department at the University of Minnesota. Dr. Nichols is a nationally-known speaker and writer on problems in communication.

"Statistics and Baseball," Robert Kingsley of the Aeronautical Chart and Information Center, USAF, St. Louis. Known as the "Home Run Engineer," Mr. Kingsley has developed formulas which enable him to arrive at comparative home run figures for parks in the major leagues. A well-known baseball figure will give a semi-humorous critique on Kingsley's talk.

"What's Behind Experimental Design," Richard S. Bingham, Jr., QC manager, the Carborundum Co., Niagara Falls, N.Y. Mr. Bingham will describe the use of statistics to get the maximum amount of information from each experiment.

"How St. Louis Police Use Statistics," Dr. Arthur C. Meyers, Jr., of the St. Louis University Department of Economics. Dr. Meyers is a statistician to the St. Louis Police Department.

"The Frequency Distribution Analysis Sheet," Ervin F. Taylor, Statistical Consultant at the Martin Co., Baltimore, Md. Mr. Taylor will describe this simple, fast, graphic quality control method and its application. Each member of the audience will be given a sheet and an opportunity to plot it.

"Statistics in a Gambling Casino," Charles C. Hirsch, Manager of Quality Control, Golden Nugget Casino, Las Vegas, Nev.

"Vendor-Vendee Relations," Otto F. Hunziker, QC manager, Central Metal Division, Continental Can Co., Chicago, Ill.

"Effective Installation of Quality Control," Francis C. McLaughlin, General Electric Co., Schenectady, N.Y.

"Handling Customer Complaints," Dale Cue, QC director, Hoover Ball and Bearing Co., Ann Arbor, Mich.

"Statistics and Weather," sub-title "Win, Place or Show," Capt. Glen H. Stadsklev, Air Weather Service, Scientific Services, Scott Air Force Base, Illinois.

"Quality Control Programs should be Cost Reduction Programs," Harmon S. Bayer, Quality Control Consultant, Detroit, Mich.

"Machine Capability Studies," Irwin A. DeGrote, QC engineer, Ford Motor Co., Detroit, Mich.

and fixed routines of inspection. Demonstration machines for sharpening the borderline between good and bad were put to daily use. Within a short time the inspector judgment was narrowed to a five percent range. In the meantime, systematic exploration of the major causes of real rejections led to noticeable improvements in quality.

One trouble, the undesirable or excessive "fork sound," was reported in some five percent of the machines. By sampling the incomplete machines just after the installation of the fork, it was found that two of the assembly lines produced uniformly good product in this respect; whereas the other six assembly lines were either inferior or excessively variable. Since the same piece parts were used, it was relatively easy to study the assembly and adjustment process and to rectify the conditions.

Elsewhere in the sub-assembly department producing shuttles, it was found that one of the lines had three times the rejections of the other two, a situation previously hidden by the pooling of product despite 100 percent inspection. Again corrective action could be taken. In this way concern for a dozen parts out of the total of 500 made for striking increases in productivity, at the same time laying the foundation for a strong quality control framework and the effective utilization of control chart and other techniques where they were necessary. Management reported productivity gains of more than ten percent.

Methods and Techniques

The six SQC Units of the Indian Statistical Institute provided starting points for the extension of quality control practices, inasmuch as the staff of some 30 statisticians and engineers had considerable plant experience and facilities for holding elementary training courses. Although other starting points were explored, the active method of disseminating quality control principles was primarily through the training courses of the SQC units, plant visits, and publicity developing from these.

Training Courses

Two-week training courses had been used by the SQC Units primarily on the model of the early courses given by Professor Ott and his associates. These courses had become heavily bookish and theoretical, failing to bring into focus the live and recent SQC experience developed in India through the work of the Units. A considerable amount of effort went into reorienting these courses bringing into them live, current experience.

Another important change was separating the two instruction weeks, and inserting a three-week interval between them. This split-week principle worked well indeed, for it provided an opportunity for the instruction staff to visit the trainees on their jobs and to suggest the actual means by which SQC could be implemented in the various companies. The second week of class concentrated on the actual progress made by the trainees in applying SQC in their plants. The visits to the plants, and instructional suggestions, generally channeled through plant management, provided the start of communications between management and the quality control groups. When management itself did attend courses, and they came in increasing numbers, the effect of training on SQC applications in the plants became much quicker and more certain. On no occasion did a manager attend a course without starting a useful application in his plant.

An Advanced Training course was given in night sessions in Calcutta over a three month period, using Dixon and Massey as a primary text. The results were disappointing for the more advanced statistical treatments did not help the industrial trainees to meet their own plant problems, which were primarily ones of position, organizational frustration and management non-response rather than statistical. Upon the basis of this experience it was considered that training at this advanced level was secondary to the other more active means of developing a larger body of practitioners.

Plant Visits and Follow-up

The most important avenue to the wider development of quality control was found in actual plant visits. These visits included those companies already members of the SQC Units, those whose students attended the training courses, and those otherwise interested. Over a hundred different plants were visited, some of them many times over. Each new plant visit was always in company with Unit personnel and was usually the occasion of some ceremony. But no matter how astute the observations during the visit, there seemed to be no lasting or tangible results without a fairly definite follow-up letter explaining in some detail the steps that should be taken to initiate or improve the quality control program. Copies of a few of these letters are included in the Appendix.

These letters provided a communication channel between management to whom they were addressed and the quality control groups in the plant and in the SQC Units. They are of course very general but they did provide a tangible basis upon which implementing management directives could be issued. In well over half the cases, the suggestions were carried into effect, in many cases with good results. Copies of the letters were filed in each of the six SQC Units to serve as a guide for use in similar circumstances. Similar letters have since been prepared by the Unit personnel as a preliminary step.

Typical Applications of SQC in a Plant

These visits and follow-up letters are made somewhat easy because they are typical opportunities for the effective employment of quality control methods in most plants. Some examples are described under the following headings:

1. *Balancing Production Efficiency*
   Jute weavers ranged in efficiency from 40 to 80 percent; spinning frames working on the same material produced surprisingly different amounts of yarn; foundry groups working with common materials produced only two-thirds of the good product of parallel groups; one sewing machine sub-assembly line had three times the defect rate as two parallel lines. Quality control methods show these differences in quantitative terms, analyze the non-common factors, and raise all units to a common level of efficiency, usually higher than the best before.
2. *Reducing Scrap and Rework*
   In an automatic glass plant, scrap was reduced from a level of 16 percent to the level of one to two percent; foundry scrap was reduced to a fourth; pottery and rubber tire seconds were halved. Quality control starts with a cause-effect analysis of scrap, determines the most likely causes, and seeks their elimination.
3. *Standardizing Quality Judgment*
   In sewing machine evaluation, some checkers rejected four times as many machines as others, causing both poor outgoing product and unnecessary rework; similar

differences in inspection standards were spotted in shoes, potteries, aluminum, and in other products. Quality control helps to establish uniform standards and to control inspection accordingly.

4. *Improving Product Quality* The outgoing quality of cotton textiles, jute, pharmaceuticals, lamps and other products improved without increase in costs, primarily through pre-engineering consumer requirements and controlling production accordingly
5. *Saving Raw Materials and Supplies* A pharmaceutical plant reduced the cost of fuel; a textile machinery plant found means to eliminate expensive imported materials while maintaining desired quality; jute mills found the means for utilizing less expensive grades of raw materials at the same time increasing outgoing product quality—all through systematic observation, measurement, and analysis. To these typical instances might be added those making maintenance procedures more effective, reducing waste, controlling weights, and a variety of others. For purposes of convenience these typical applications can be organized in the form of a scoring sheet or check-off list so that the places of maximum potential gain can be quickly noted during a plant visit.

An Industry-Wide Approach

After visits to two or three jute mills, the problems disclosed and the suggested pattern of approach to quality control appeared to be much the same for all. Most mills faced essentially the same problems. It was therefore possible to develop a general approach on the basis of a few visits that would be useful and meaningful to all the mills in the industry. These approaches were called industry briefs and were circulated through the trade associations. They provided concrete *modus operandi* appropriate to Indian conditions as given in the follow-up letters, but of course lacked the personal touch and direct contact with top management. Nevertheless these industry-wide prescriptions for quality control attracted a great deal of interest and encouraged many of top management of the jute industry to attend training courses in quality control.

Similar industry-wide approaches were projected in other industries, plywood, pharmaceuticals, foundries, and potteries. They provide not only for specific applications in industries, but also for the background knowledge that Unit quality control practitioners need in approaching new plants and in standardizing their techniques.

Consumer Goods Testing

The comparative testing of consumer goods purchased from the market place provided another avenue for exploring where quality methods might be advantageously used. This avenue was explored very slightly for in India there is yet nothing comparable to *Consumer Reports*[2] providing objective quality comparisons of consumer products on the USA market. Two projects were started: one dealing with ordinary glass tumblers; the other with box safety matches.

Common glass tumblers of the same price class, made by some eight different manufacturers were purchased from the market in Calcutta. The object was to score the quality of the different manufacturers and to use relative position in the quality scale as leverage with which to approach the manufacturers. Most glass plants in India are small and use either hand or semi-automatic equipment. A direct approach to each plant would be time consuming and costly, for it takes just as long to convince a manager of a small plant of the need for better methodology as it does to convince the manager of a large one. It was reasoned that an approach supported by incontestable market facts might be quite effective.

The glass tumbler scores based upon a carefully designed sampling plan showed startling differences in quality between manufacturers, the objective score of the poorest being only about a third that of the best. The information was presented at the Indian Standards Institute meeting in New Delhi in coded values and also sent to each of the manufacturers. Time did not allow a complete follow through nor a real test of the effectiveness of this approach.

One side effect of the consumer oriented approach, however, was the development of a satisfactory test method. When the first token sample of glasses was examined, the examiners differed more in their judgment than did the products. In the several successive rewrites of the instructions for evaluation, the differences between examiners were studied and narrowed down until the point came where an outside group of examiners could attain essentially the same scores on the different glasses. This training in the proper preparation of a classification of defects or inspection instruction, based upon reducing the error of observation to satisfactory levels, provided invaluable training for actual quality work in the plants.

Safety matches were also evaluated from a consumer quality standpoint. This developed from the Unit training courses at first, for the small boxes provided an easily used class-room device for preparing an inspection instruction and for evaluating the product of the different manufacturers. The quality characteristics examined were the number of matches per box, the number broken or defective, and the condition of the box and slides. The quality differences were so pronounced that the students could easily detect among the different manufacturers where better control of processing could be effectively employed. This information did get to the match manufacturers and there were persistent calls for assistance in quality control from them.

Despite their limited usage here, consumer goods quality evaluations provide an excellent starting point for stimulating the development of a national quality control program.

Export Quality Control

There is some interest in India in the use of quality standards for exported handicrafts through the Handicrafts Board, but most of the present handicraft products flowing into the export market depend so much upon artistic skill and workmanship that not much has been done than to assure the authenticity of the materials as represented—ivory rather than bone —and so forth. There appears to be little parallel to the Japanese case. In Japan exports play so important a part in the domestic economy that rigid quality control of exports in the post-war market has been a most effective instrument in extending the internal use of quality control techniques.

In India one unfortunate case of export quality control was observed in the case of druggets, the hand-woven rugs made of tanners wool. At the same time that attempts were made to impose export quality standards, the increasing cost of tanners wool and the development of synthetic fibers

abroad for rugs in this price class almost completely destroyed the foreign market. Quality control has not escaped criticism in this fiasco.

National Meeting on Quality Control

The National Conference on Quality Control held in Calcutta at the end of 1958 exemplifies another method of developing and extending SQC in India. Some 250 people, representing top and middle management and SQC practicioners, attended the three day session. More than 60 papers and reports were given, mostly dealing with the development of recent quality control programs. The papers were drawn from over 20 industries and reflected the considerable progress made in the application of quality techniques. The conference was a most enthusiastic one, and the spirit of accomplishment on the part of those who participated was dominant. The conference was jointly sponsored by the Indian Statistical Institute and the National Productivity Council.

Conferences of this kind accomplish many purposes. First they provide illustrative material which others might follow. Second, they bring quality control work of individuals or groups within a plant to the attention of their own management in a manner not possible in internal reports. Third, they engender confidence on the part of those who have done the work. And last, they engender group morale on the part of all those engaged in quality applications arising from the scope and intensity of the applications. All these are necessary in the development of a national program.

The particular conference in December 1958 provided a great deal of factual material on the quality control developments in India. This together with other observations are summarized in the following notes on some of the industries:

Sewing Machines A plant-wide application has helped to save ten to 20 percent rework, increased efficiency of processes by balancing assembly and sub-assembly lines, and helped to raise productivity by more than ten percent. (An export item).

Jute Products Industry-wide applications appear to be in prospect aimed at raised spinning and weaving efficiency (on the order of ten percent) reducing raw material costs, and raising outgoing product quality. Some 20 mills out of the national total of 100 have active SQC programs.

Cotton Textiles Many applications throughout the 500 mills in the country are spurred by the three Textile Research Associations, by private consultants, and by the SQC Units. Some mills report 20 percent increases in weaving efficiency through quality control, reduction in waste, and product improvement.

Foundries Many applications in large and small foundries throughout the country, many of them reporting very significant reductions in scrap and defective castings, and increases in production. One large foundry reported reductions in defective castings from 30 percent to less than ten percent through reinforced molds, improved cores, and better controls of sand initiated through the quality efforts.

Bicycles and Accessories There are strong SQC applications in several of the plants. One reports reduced painting rejections from 25 percent to less than five; another reduced rim rejections from 35 percent to less than seven. (India is becoming a nation on wheels — on bicycles made in India).

Glass In a large automatic glass plant, SQC helped to reduce the 16 percent rate of rejections to less than half, with great increases in the quality of product, especially that going to the pharmaceutical industry.

Pharmaceuticals Many applications in a large number of relatively small plants. Significant improvements have been reported in product quality especially in the elimination of foreign matter in vials, correction of loading problems of bottles and caps, and the provision of uniform weights for tablets and capsules. Increased emphasis on quality standards in related bottling sidelines.

Potteries In a large pottery, very significant reductions made in the amount of scrap or broken plates and the proportion of seconds through control charts and other statistical devices. Differences in roughness of automatic ovens revealed as cause in addition to lack of training of molders.

Shoes In a large factory SQC methods detected and helped to eliminate the ten percent substandard shoes previously sent to the market.

Aluminum In a large rolling mill, quality methods helped to reduce final rejections and scrap through improvements of tempering methods and rolling processes, adding a dynamic quality note in a plant where control charts had been previously used primarily for plate thicknesses. A quality committee covering all departments was established to coordinate design as well as production improvements.

Electric Lamps In a relatively small plant statistical design of experiments led to greatly improved length of life of bulbs, and reduction of scrap of automatic bulb making machines.

Cigarettes Quality methods led to effective control of machines producing imperfect cigarettes; controlled moisture and weights. Methods used in many plants.

Biscuits Provided means for control of biscuit and packaging weights and for improvement of products.

Soaps Disclosed existence of nearly fifty percent process run-around owing to faulty cake solidification and cutting. Control charts used extensively in laboratory tests. Methods also helped to improve packaging quality.

Cement Revealed that over 75 percent of bags were shipped under-weight unintentionally as a result of automatic weighing machine errors and faulty sampling controls. Methods helped to reduce this percentage to less than six, while raising the average bag weight by less than two pounds. Extensive applications considered in control of particle size in slurry and in the balancing of fuel consumption of kilns.

Textile Machinery Statistically designed experiments led to reduction of blade breakage and conservation of expensive imported materials. Many partial SQC applications in some of the plants.

Telephones Large numbers of control charts in machine shops did not keep defective units from assembly lines. A more dynamic quality approach, starting from evidences of unsatisfactory product, e.g., noisy dials, seems to be working.

Typewriters Large numbers of machine shop control charts but no effective controls in assembly operations and in final evaluation where needed.

Abrasives Effective plant-wide quality program developed with reduction of wheel breakage and paper scrap, replacing the spotty and partial control chart operation previously used.

Prospect for Future Development

Letters and reports received from India during the past year indicate that the promising start

in the use of SQC methods has continued, although not without some backward slippage. In the progressive northwestern area, the Baroda Unit has all the plants in its region as members, while the Bombay Unit has a waiting list. In the relatively unindustrialized north center, the New Delhi Unit reports heartening progress with new returns in the sugar industry and into hotel applications. In the South, the Bangalore Unit reports the addition of many new member companies. The Calcutta Unit, however, reports some setback with respect to its membership possibly, attributable to the absence of the unit head on training in England. Altogether there appears to be a lively and continuing interest in actual applications.

This interest still does not appear to be reflected in the size of the membership roles of the quality control societies. One may have to accept the fact, however reluctantly, that the ASQC pattern may not be the only way of developing a national quality movement.

In this last year, too, two of the unit heads have had six months on the job training in England and others are expected soon in this country. There is every hope that they will return to their homeland with renewed enthusiasm and with clear examples of effective SQC applications to follow. Their difficulty, besides that of finding good, single-plant examples, is that in this country and in England there is no comparable governmental group vested with national responsibility for SQC.

Summary and Observations

1. Statistical quality control techniques, properly applied, can be one of the most effective means of increasing the productivity of established Indian industries.
2. Individual plants in the increasing variety of industries are starting to use these methods.
3. Management of Indian industry is responsive to the application of these techniques, provided they can be shown in concrete terms where they apply to their own enterprises and to Indian conditions.
4. The SQC Units of the ISI, with their training and follow-up facilities, in-plant assistance and promotional activities, provide the strongest nucleus from which a national quality control movement might spring. The USA pattern of SQC growth through a strong professional society does not appear to be easily transplanted to Indian soil, nor does the Japanese pattern of development through strong control of export quality.
5. India provides a most suitable training ground for those interested in the "macro" application of quality techniques. In addition it has great resources of mathematical and statistical skills which can be turned in industrial pursuits and which might serve broader purposes in the free world.
6. The possible use of quality control techniques as one of the most effective instruments of technical assistance to the underdeveloped nations of the world should be of strong and increasing interest to the members of this society.[3]

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2. *Consumer Reports*, published monthly by Consumers Union, Inc., Mount Vernon, N.Y.
3. William R. Pabst, Jr., "Use of Statistical Quality Control in the Industry of Underdeveloped Countries," *Industrialization and Productivity*, March, 1960 United Nations, N.Y. Also see Pabst, Statistical Quality Control in India, United Nations *Report TAO/Ind/33*, Mar. 4, 1960

Letter to the Manager of a Fan Factory

My preliminary observations, based on the brief visit and similar situations elsewhere, are that the first important step of the quality control person should be to systematize and utilize the final inspection observations, then systematize incoming inspection, and finally the machine shop. Some details on these steps are given in the following:

1. Final Inspection

Situation: at the present time there is a considerable percentage rejection of fans at the final inspection. Speed in RPM and power consumption are checked. Causes of rejection of individual fans are noted in the inspection book, but no summary is available. Many of the table fans were apparently rejected for poor regulation, the cause of which should be easily isolated and correctable. Apparently the different lines vary considerably in the rate of rejection.

Action suggested: Final inspection records should be summarized over the past month for each line as a guide to action. The rate of rejects for each line should be plotted on a control chart. The reasons for the individual rejections should be summarized and investigatory action should be taken with the most important ones. This may show where manufacturing, processing or assembly quality controls are necessary.

The parallel was encountered in sewing machines. Enumeration of causes of rejection, after inspection was standardized, led to the tracking of reasons for shuttle and fork sounds. Corrective action is being taken in shuttle sub-assembly for the first, and on the assembly line for the second. These strategic points were located after considerable study.

Additional attention might be given to the inspection procedures for fans: There was no indication that fan blades or guards were checked at the final stage or that possible 'minor faults' were noted. Once the final inspection is strengthened and stabilized, and the obvious causes of rejection corrected, a systematic measuring of outgoing quality should be established by means of a small sample check inspection just before packing. This will provide a real control on production test and assembly operations.

2. Incoming Material

Situation: Inspection of incoming material is apparently conducted, but there is little indication that records are maintained or utilized. Control of incoming material can become one of the most effective and important controls in the plant. Some material now is sorted out and returned to the supplier (fan blade guards), but the quantity of this return, the reasons for defective classification, or the usability of the remaining stock is not assuredly known. Aluminum sheets were said to be returned to the supplier for deep scratches, but no indication that actual returns had been made is available. Ball bearings are checked apparently on a sample basis, but explicit sampling plans or the basis for lot acceptance and rejection were not found.

Action suggested: For the important incoming assemblies and raw materials, a systematic effort to evaluate incoming quality for each supplier should be made with the assistance of MIL-STD-105A sampling tables. For each such product a careful inspection procedure will need to be established (sometimes in consultation with the supplier) and a lot-by-lot check inspection made and recorded. Information thus obtained should enable the determination of practicable acceptable quality levels for each type of material.

Such control of the quality of incoming materials will (1) make it possible to isolate non-acceptable suppliers (2) return reliable information on the causes of rejects to

suppliers to secure corrective action in the supplier's plant, and (3) reduce processing operations due to sub-standard materials (e.g. scratched fan blades).

3. Machine Shop

Situation: Considerable screening or 100 percent inspection exists after many machining operations. The present record books are difficult to interpret, but they seem to show (1) that rejection is usually small and confirm operator's statements that it is about one percent, and (2) there is considerable difference among operators on the same machine with respect to scrap and rework rates.

Action suggested: Attention might be devoted to this after a satisfactory system is operating on final inspection and incoming material. Important thing first is to find from final inspection where processes need closer control than now provided and concentrate on these strategic situations. Thereafter a control chart inspection on the machine, or a sample lot inspection check, can be substituted in turn for most of the 100 percent inspection now practiced. The object of the sample checks is to control the process and prevent the production of defects, rather than finding them by detailing and later correcting the observed defects as at present.

These broad suggestions are offered as a general guide for the development of a quality control system. As you know, progress in the installation of a quality control system may be slow, but it must be determined. The object must be to save in costs, better utilize facilities, eliminate unnecessary plant runaround and rework. Gradual accomplishment of the above three steps should work toward the accomplishment of the cost-saving objectives and lead to a complete quality system.

Sincerely yours,
Sd: William R. Pabst, Jr.

Letter to a Jute Mill Manager

Quality control methods cannot be imposed by an outside authority, but rather must develop within a plant. These methods put in scientific form much of the information that has been ordinarily collected in the past. These scientific methods attempt to search out the strategic factors that dominate a process and to develop methods of control of these factors. The extent of control that is necessary depends upon economic considerations, for these methods must prove themselves in increasing productivity, saving costs and improving the quality of output. Our plan of implementation is as follows:

1. As agreed in our meeting, the first application of quality control methods will be in the spinning stage of the process. The overall purpose here is to utilize the present spinning equipment as effectively as possible in turning out yarn, to indicate the men, frames and spindles that are significantly below the rest, and to study maintenance procedures on the frames with a view to their optimization.

The first task in working toward this objective is to evaluate the present state of efficiency frame by frame. To do this, a systematic snap check reading of ends down will be taken four times a day at random intervals. This will be similar to but much more extensive than the initial reading we took yesterday in which we counted 23 ends down on one frame and two ends down on the frame next to it working on the same yarn. This information recorded over a week's time will serve to determine the basic level (in ends down) at which frames might be expected to operate for each class of yarn. The frames departing from this determined level either continuously or spasmodically will then be indicated for special attention by the spinning master and maintenance crew.

The second task will be to make frequency distributions of end breaks spindle-by-spindle for the frames lowest in efficiency. The object here will be to designate those spindles giving performance very much inferior to the others and to secure their correction. It will also be to study correction needed for these poorer spindles in the light of a preventive maintenance policy.

Operations connected with spinning may also be studied under this first application in connection with the tracing of the reasons for departures from established standards of performance back to their basic causes, and to necessary corrective action. This first application should be reasonably well established *at the end of one month.*

2. The second application is planned for the evaluation of outgoing material and will be initiated *during the second month.* The objective here will be to evaluate product quality to ensure that the entire process of mixing, spinning, weaving and inspection results in the quality of material that is intended. If not, the information will be at hand to determine the strategic processes and apply whatever measures are necessary to control these.

The mechanism of this second application will be to establish a check evaluation based on a sample of 16 to 32 cuts per day. These cuts will be examined on a systematic scoring scheme whose detail will disclose wherein process troubles may exist. Actual procedures will be spelled out in due course for implementation at the mill.

3. The third step to be taken *in the third month* will depend to some extent on the findings of the second, but will probably be a systematic application of quality control at the weaving stage. For this, measures of the efficiency of looms on the different fabrics will be studied to determine reasonable standards, and to note significant departures from these. A concerted attempt will be made to narrow the differences in efficiency among the individual weavers so that the looms may be utilized closer to their capacity.

Data already available from efficiency payments to the individual weavers may be utilized in this aspect of the work, and will be supplemented by snap check readings as necessary. More systematic control of faults at the looms may also be found necessary.

4. The fourth and last step (interchangeable with the third) will be to introduce more systematic control of batching based on available information on the relationship of spinning and weaving efficiency and batch cost. The purpose will, of course, be to work continuously toward the optimum batching.

The mechanism will be to determine the stabilized spinning and weaving efficiencies related to the different batch compositions and their costs, and to study this relationship through correlation techniques. This information should supplement the experiences and skill of the mill in arriving at optimum batching.

This four-month program is designed to keep the quality control application moving along at a consistent and reasonable speed and to allow for the training of mill personnel during its course. Within a year's time, it is considered that the mill should be able to go forward on its own with the application of quality control methods. The primary endeavor of the SQC Unit assistance will be to put the mill in such an independent position with respect to quality control.

It is hoped that this program will meet with your favor and that you will guide it to an economic and practicable conclusion.

Sincerely yours,
Sd: W. R. Pabst, Jr.

Letter to a Soap Manufacturer

The lively discussion of the use of Quality Control techniques which may contribute to your developing programme was most interesting to me. You and your assistants are apparently aware of the great gains that can be made through SQC in the several areas. For purposes of record let me recall them as follows:

1. *Elimination of unnecessary scrap at the cutting of the soap cakes*

As indicated, there are nearly 30 percent turn-around at this point, thus involving unnecessary rework and diminution of your production capacity. What is necessary here is

a systematic record of the amount of rejects at each cutting bench, the differences between time as measured in days or weeks, and the difference between operators. This information may be gathered on a complete basis or by sampling, taking half-hour periods during the morning and afternoon shifts to provide the necessary statistical information. The data should also include classification by cause of rejection and this should lead you soon to the corrective action needed. My impression based upon observations in other plants as well as of your excellent staff is that you will be able to reduce the amount of rejection at this point from the present 30 to less than ten percent.

2. *Difference in inspection standards*

As you remember, we watched the different inspectors rejecting the soap cakes after stamping. It appeared that the standards of these inspectors differed very much. Presumably some of the material rejected by "tough" inspectors is passed by others; consequently some poor material goes on to wrapping. Quality control should introduce proper standards for inspectors on all the lines so as to achieve a uniformity of acceptable product.

3. *Wrapping of soap*

Quality control can be usefully applied to the wrapping of soap in order to achieve uniformity among the different wrapping machines throughout the plant. It was claimed that there was some five to seven percent loss at wrapping, possibly higher in the case of small soap cakes. Some of this loss may be attributable to different machines and to different maintenance. In other similar cases we have found that the difference between individual wrapping machines accounts for a substantial part of this loss, and that this generally can be corrected.

4. *Outgoing Quality of Product for Soap*

The measurement of outgoing soap quality including the packaging of soap cakes that now get through 100 percent detailed inspections might easily be measured. The finished cakes are now put into boxes for shipment; a valid procedure would be to take a random sample of about 32 cakes per shift for each machine. These cakes should be examined carefully and scored for defects in wrapping and defects in the cake itself. My impression was there is a percentage of both defective wrapping and dirty or spotty cakes now going out of the plant in most kinds of soap. My impression also is that most of these cases are unnecessary and can be avoided.

5. *Weight of Soap Chips*

Quality Control study should be made of the weight of soap chips and their packing material. Your present procedure seems to be biased on the heavy side, for the girls tend to fill up to a given weight. It is possible that the packages average nearly a quarter ounce overweight. This can be easily checked through quality control techniques and procedures set up for arriving at very close weight distribution about the average that you desire.

As to the other places for quality control, as in the chemical control of soaps, it appears to me that this is now well in hand through your laboratory. If the more obvious things are done in the wrapping and cutting plant, it may be that Quality Control techniques may be used in Laboratory in gaining long-run as well as batch-to-batch control of the basic materials.

As for the raw materials sampling, special problems are encountered here, particularly in your need to sample each barrel. Probably better control is not of our immediate concern, but I suspect that you will do very well to add tests of four individual barrels from each shipment in addition to the test of the composites that you are now making. This test on individual barrels will give you the measurement of the differences among barrels; better information of the character of the lot thus obtained may help in many ways in the batch control of your processing.

Sincerely yours,
Sd: William R. Pabst, Jr.

Letter to the Manager of a Pottery

Your plant has many modern features with its beautiful oven and the automatic controls. Your products—especially on the sanitary-ware side—are in great demand. You are handicapped to some extent by the raw materials available, by the amount of scrap and rejects that occur, and by the capacity of oven space. Quality control methods may help to overcome to some extent each of these limitations.

1. *Raw Materials*

The iron content of the clay that you receive from local sources comes as the result of faulty processing of the clay. The iron tends to discolor the china after baking. Since you apparently cannot reject lots of clay, the only thing that you can do is furnish your supplier with an account of the impurities of the clay. At least two samples from the incoming material might be sent to a laboratory for analysis, possibly at one of the colleges or governmental labs in your region. This will establish whether your supplier is consistently faulty, or has good and poor shipments. If the latter, you will do well to try rejection of the poorer lots received. If the supplier is consistent, then bring to his attention the condition of the material received; this may have the effect of getting him to improve his process in this respect. Ultimately he will have to improve or you will have to install processing machinery if satisfactory products are to be obtained. Apparently the quartz and felspar are satisfactory.

2. *Scrap and rejects*

The high rate of rejection on both the sanitary-ware and on the china needs thorough study of cause-effect relations. Many of the troubles apparently can be tracked back to the molds or to the molders, but a method of tracing this information systematically is needed. The first thing that is necessary is a scoring system or check-off list of the observed kinds of defects so that each day's production can be scored by the number of good pieces, and the number of defectives of various categories. The second thing that is needed is a method of identifying the original mold and molders (or group of molders) so that the comparative scores of these groups day by day can be obtained. This segregation is of utmost importance, for if experience in other potteries is relevant, it may be found that some groups do an excellent job; whereas others do an imperfect one. The object is to get all groups at the same level through training, instruction or other procedures, but this cannot be done until it is learned which groups need such improvement. Additionally the different rate of defects for the different kinds of china may provide the clue as to necessary changes in processing.

Incidentally, the present method of sorting into firsts, seconds and rejects needs careful review to remove what appears to be large differences in inspection judgment. Visual samples of just good and just bad pieces of each kind of usual defect may be helpful in bringing all the inspectors into a common judgment. Assembly of material to be sorted into discrete batches may also be helpful in avoiding this commonly found bias.

3. *Utilization of the oven*

Since the space in the oven is the critical and limiting factor in production, your efforts to utilize as fully as possible the available 32 cubic feet of each truck should be continued.

You might measure the actual cube used by each of the kind of loads you now make and start exploring as to how to raise the lowest of these. The short-time advice of a geometrician might be most helpful to you in this regard.

My feeling based upon the short visit to your plant is that very considerable progress can be made—especially in reducing drastically the rate of defects.

Sincerely yours,
Sd: William R. Pabst, Jr.

A TEST

for Determining

Which of TWO Variables Is Better for Predicting A THIRD Variable

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Sometimes it is necessary to determine whether or not one variable is better than another variable for predicting a third variable. For example, the weight of a steel object may be better predicted from one measurement than from another. The BT units from coal may be better predicted from the percent of carbon than from the volatile matter. A steer's weight may be better predicted from the heart girth than from the length. Area of leaves may be better predicted from width than from length.[1] Sometimes it is more convenient to measure one variable than another.

Before Hotelling[2] found a test for solving this problem, some tested for significant difference between the standard errors of estimate pertaining to the linear relation between the first and third variables and then between the second and third variables. This is not correct since the standard errors of estimate are correlated.

The Hotelling test requires that corresponding measurements be made for the three variables; which means that n measurements be made for each of the variables under consideration. In the illustration considered here, 12 scores were determined on desirability, texture, and flavor of fish. The scatter diagrams of Figs. 1 and 2 contain 12 points. The requirement assures that the various correlation coefficients are based on the same number of measurements. Degrees of freedom for the test are n — 3.

Hotelling's test will be applied to determine whether or not flavor scores are better for predicting desirability scores of fish than are texture scores. Figures 1 and 2 exhibit the scatter diagrams of desirability scores and flavor scores and that of desirability scores and texture scores, together with the lines of best fit.

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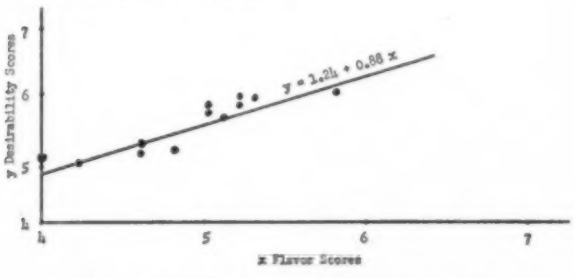

Figure 1—Relation of Flavor and Desirability of Fish

The equations of these lines of best fit and their standard errors of estimate are:

$$\hat{y} = 1.24 + 0.88x \pm 0.11; \quad r_{yx} = 0.98$$

$$\hat{y} = 1.35 + 0.70z \pm 0.23; \quad r_{yz} = 0.87$$

where $\hat{y}$ represents predicted desirability scores and x and z represent respectively flavor and texture scores.

Hotelling's test is as follows:

$$t = (r_{yx} - r_{yz}) \sqrt{\frac{(n-3)(1+r_{xz})}{2D}}$$

where

$$D = \begin{vmatrix} 1 & r_{yx} & r_{yz} \\ r_{yx} & 1 & r_{xz} \\ r_{yz} & r_{xz} & 1 \end{vmatrix} = \begin{vmatrix} 1 & 0.98 & 0.87 \\ 0.98 & 1 & 0.81 \\ 0.87 & 0.81 & 1 \end{vmatrix}$$

hence

$$t = (0.98 - 0.87) \sqrt{\frac{9(1.81)}{2(0.0078)}} = 3.55$$

which is significantly larger than zero at nine degrees of freedom. This means that desirability scores of this type of fish are better predicted from flavor scores than from texture scores.

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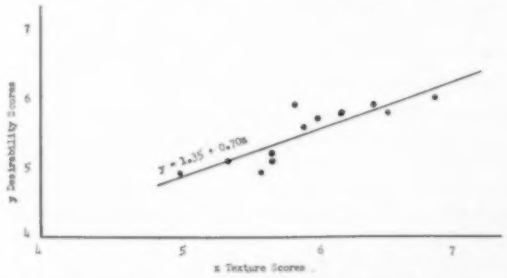

Figure 2—Relation of Desirability and Texture of Fish

On the Distribution of Products

And Quotients of Random Variables

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Introduction

In the combining of material, or fabrication or assembling of parts, we frequently find that the performance characteristic of the resultant materials is some known function of certain variables. Thus the cross-sectional area of a rectangular copper wire depends upon the width, x, and thickness, y; in fact it is xy. If we know the distributions of x and of y, and how they are correlated, then what can we say about the distribution of $z = xy$? Additive and subtractive functions, such as, $x_1 + x_2 - x_3$, have been written about fairly extensively.[1] Results for more general classes of functions to a first approximation can be found in some mathematical statistics books.[2] Higher moments are available by further application of the methods for finding the variance of a combination of variables. Comparatively few results on the exact sampling distributions of the product and quotient of random variables are known, although methods for finding them have been known.[3] The trouble is that either the integration cannot be performed, or else the resulting function is split up into so many parts that it is quite messy.

A most interesting series of papers[4] by John Tukey has very recently appeared, subsequent to my start to work on this article. Tukey's work substantially completes the job in much generality, including functions of non-independent variables, and quite arbitrary functions. His work is largely concerned with providing the first four moments of the function, which he plausibly regards as sufficient for practical cases. He does not show exact sampling distributions, which of course would require innumerable special cases, with any real generality being impossible.

We shall give here in an expository manner some results in the same form as Tukey's and two exact sampling distributions, for illustration.

Moments

Before going into results for various functions, let us first define certain moments for random variables. Defining the letter E to indicate the theoretical average value of any quantity in parentheses or brackets following it, we have population characteristics

$$\bar{x}' = E(x) \tag{1}$$

$$\sigma'^2 = E[(x - \bar{x}')^2] \tag{2}$$

$$\mu_3 = E[(x - \bar{x}')^3] \tag{3}$$

$$\mu_4 = E[(x - \bar{x}')^4], \text{ etc.} \tag{4}$$

$$\alpha_3 = \frac{\mu_3}{\sigma'^3} \tag{5}$$

$$\alpha_4 = \frac{\mu_4}{\sigma'^4} \tag{6}$$

The last, if we subtract 3 from it, has been called "excess," while (5) has often been called "skewness,"

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since it is a measure of lack of symmetry. The respective values of α_3 and α_4 for a normal population are zero and 3, while for a rectangular population, they are zero and 1.8. We usually use sample moments from which to estimate such population moments. We need large samples to estimate α_3 and α_4, because the estimates are subject to rather large sampling errors. For example, if the population is normal, they are approximately $\sqrt{6/n}$ and $\sqrt{24/n}$.

When two variables are not independent we make use of joint moments. Suppose we have variables x_1 and x_2. Then letting the first subscript relate to x_1, the second to x_2 we have, for example,

$$\mu_{11} = E[(x_1 - \bar{x}_1')(x_2 - \bar{x}_2')] \quad (7)$$

$$\mu_{23} = E[(x_1 - \bar{x}_1')^2 (x_2 - \bar{x}_2')^3], \text{ etc.} \quad (8)$$

$$\alpha_{23} = \frac{\mu_{23}}{\sigma'^2_1 \sigma'^3_2} \text{ etc.} \quad (9)$$

Note that

$$\alpha_{11} = \frac{E[(x_1 - \bar{x}_1')(x_2 - \bar{x}_2')]}{\sigma'_1 \sigma'_2} = \rho \quad (10)$$

the population linear correlation coefficient. Note also that α_{03} in (9) would be the same as (5) for x_2, etc.

Finally we define the coefficient of (relative) variation by

$$V_x = \frac{\sigma'_x}{\bar{x}'} \quad (11)$$

Some Results for Products and Quotients

The practical cases of importance would seem to be those in which the component variables are never (or at least almost never) zero or negative. For the most part they will have coefficients of variation, V, not larger than 0.1 and often 0.01 or less. Under such conditions we can give accurate and useful formulas, involving few terms.

Independence or lack of independence makes quite a difference in the formulas, so we take up the simpler case assuming independence first. Then we can prove

$$E(xy) = \overline{xy'} = \bar{x}'\bar{y}' \quad (12)$$

$$\sigma'^2_{xy} = \bar{x}'^2 \sigma'^2_y + \bar{y}'^2 \sigma'^2_x + \sigma'^2_x \sigma'^2_y \quad (13)$$

The third term on the right of (13) will usually be quite negligible relative to the others, in practical cases of interest. Another form of (13) is obtained by dividing (13) by the square of (12) and using (11), getting

$$V_{xy}^2 = V_x^2 + V_y^2 + V_x^2 V_y^2 \quad (14)$$

For higher moments, measures of curve shape, we have approximately

$$\alpha_{3:xy} \approx \frac{V_y^3 \alpha_{3:y} + V_x^3 \alpha_{3:x} + 6 V_x^2 V_y^2}{[V_x^2 + V_y^2]^{3/2}} \quad (15)$$

$$\alpha_{4:xy} \approx \frac{[V_y^4 \alpha_{4:y} + V_x^4 \alpha_{4:x} + 6 V_x^2 V_y^2 + 12 V_x^3 V_y^2 \alpha_{3:x} + 12 V_x^2 V_y^3 \alpha_{3:y}]}{[V_x^2 + V_y^2]^2} \quad (16)$$

For quotients we have similarly, but more complicated:

$$E(x/y) = \frac{\bar{x}'}{\bar{y}'} [1 + V_y^2 - \dots] \quad (17)$$

$$V_{x/y}^2 = V_x^2 + V_y^2 - 2\alpha_{3:y} V_y^3 + \dots \quad (18)$$

$$\alpha_{3:x/y} = \frac{\alpha_{3:x} V_x^3 - \alpha_{3:y} V_y^3 + 3(\alpha_{4:x} - 1) V_y^4 + \dots}{[V_x^2 + V_y^2 - 2\alpha_{3:y} V_y^3 + \dots]^{3/2}} \quad (19)$$

As an example for the case in which x and y are not independent, we have

$$V_{xy}^2 = V_x^2 + 2\rho V_x V_y + V_y^2 + 2 V_x V_y (\alpha_{12} V_y + \alpha_{21} V_x) + \dots \quad (20)$$

Examples of Exact Sampling Distribution

The exact sampling distribution of a product or quotient involves a problem of integral calculus. Basically one simply finds the probability that xy or x/y lies below any given value. Following this approach we have found the exact distribution for two independent rectangular distributed variables x, 17 to 23, and y, 8 to 12. The sampling distributions for their product and quotient are given in Fig. 1 and 2. There are three portions in each, one straight and two curved. (In a special case the straight portion could

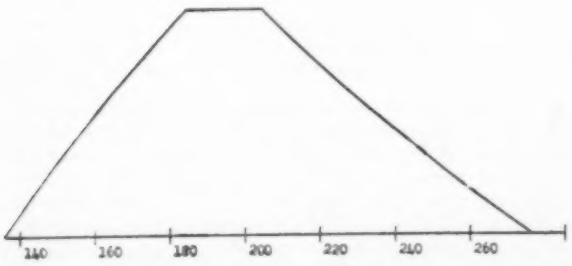

Figure 1—Frequency Function of z = xy, Where x and y Have Rectangular Function, x 17 to 23, y 8 to 12

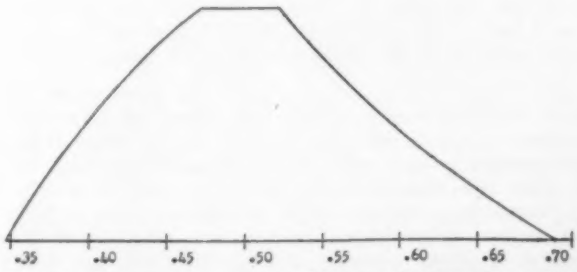

Figure 2—Frequency of w = y/x, Where x and y Have Rectangular Functions, x 17 to 23, y 8 to 12

vanish.) These are quite similar to the distribution of two unequally variable rectangular variables as in Reference 1.

Use of Transformations

It is possible to gain great simplification in formulas by transformations which make the variables additive. Thus for $z = xy$ etc. we can take logs of both sides. Then if we call $\log z = Z$ etc. we have

$$Z = X + Y \qquad (21)$$

In general, if we know the distribution of x, we know it also for X, etc. The function (logarithm) to take here was obvious. But in many cases it may not be clear what to use. Tukey points out that whenever the function of the variables is always-increasing or always-decreasing in each of the variables then there is always a transformation which makes the function a linear function of the transformed variables. Although possible, in such general cases the transformation may be complicated.

Other Functions

A wide variety of functions can be handled by these methods. One classical result, for example, in Reference 2, for variance gives for $z = f(x_1, \ldots, x_k)$

$$\sigma'_z{}^2 \simeq (z_1)^2 \sigma'_1{}^2 + \ldots + (z_k)^2 \sigma'_k{}^2 \qquad (22)$$

where z_i is the partial derivative of z with respect to x_i, with the mean values substituted in for each x. Tukey shows that this formula is better than might have been expected, and he also gives formulas for higher moments. The latter help considerably, because they give information on curve shape, which is helpful, since the exact distribution is usually unknown.

As an example we may take the case of two eccentricities, x_1 and x_2, combining at random angle, A, so that the combined net eccentricity is

$$z = \sqrt{x_1{}^2 + x_2{}^2 - 2\,x_1 x_2 \cos A} \qquad (23)$$

We want to know what the distribution of z is. A second example is that of the distribution of the solution of a quadratic equation

$$x_1\,z^2 + x_2\,z + x_3 = 0 \qquad (24)$$

where x_1, x_2 and x_3 are random variables. This problem was written on by Hamblen.[5]

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Performance Characteristics Of Acceptance Sampling Plans

FOR IN-USE TESTING OF ELECTRIC METERS

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DURING the last few years the public utility commissions of several states have approved sampling plans for testing electric meters in use for accuracy, in some cases on a trial basis. In many states 100 percent inspection each six or eight years had been required. Proposed plans are under consideration in other states so that it appears likely that such plans will be widely used before long.

A common feature of a number of these plans is that after the meters have been separated into lots according to characteristics thought to be relevant to performance, each lot is to be sampled annually as long as the sample meets the acceptance criterion. If, however, a sample leads to rejection, the entire lot is then to be 100 percent tested within a given period of years (usually shorter than the previous one for periodic testing of all meters), the lot being withdrawn from sample testing until the rectifying inspection is complete.

It then becomes of interest to follow not only the operating characteristic (OC) curve from year to year for a given lot quality, but also to find the average outgoing quality (AOQ) curves and the average total inspection (ATI) curves for such plans.

ALL but one of the proposed plans I have seen are single-sampling plans. Some are for attributes inspection only; some are for variables inspection only; and some incorporate both kinds of plans. For simplicity and with slight effect on the accuracy of results, I will assume that all samples after inspection are returned to the lot which is then either accepted *in toto* or put on rectifying inspection. Rectifying inspection is assumed to begin immediately and to be

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completed at the uniform rate of one rth of the lot per year, including the year in which the sample was taken.

Then OC curves to show the probabilities, $P_a(k)$, that a lot of incoming quality, p, has not been rejected by the end of k years are immediately obtained from the relation:

$$P_a(k) = [P_a(1)]^k$$

in which $P_a(1)$ is the usual P_a for the acceptance plan applied but once, which is the case for the ordinary use of acceptance sampling in receiving inspection. For example, suppose that inspection is by variables (meter accuracies are usually measured to the nearest 0.1 percent) and that for a lot of size $N = 10{,}000$, we use the MIL-STD 414[1] plan for the AQL = 2½ percent which calls for a sample of $n = 75$. Then from the appropriate OC curve in MIL-STD 414 we read the values of $P_a(1)$ for selected values of p. These are shown in Table I along with other values of $P_a(k)$ which were calculated from them. Values of $P_a(1)$ could be read from the curves to three places of decimals at most. For this reason, values in the remaining tables—all of which are calculated from entries in Table I—are given to a maximum of three significant figures.

Even though a five percent defective lot has nearly a 50-50 chance of escaping screening inspection the first year, the fact that it has a small chance of slipping through for four years and negligible chance of doing so for eight years is likely to be reassuring to public utility commissions.

THERE is a little more to the calculation of AOQ's. In fact it appears that two kinds of AOQ's may be of interest. In the usual receiving inspection application, the AOQ is the average outgoing quality after the screening inspection of rejected lots has been completed. In the present case, even though the 100 percent inspection is to be spread over r years, we can calculate for any year the AOQ that *will* result on the completion of the rectifying inspection called for by the rejection of lots in the current and previous years. I will call this a Type 1 AOQ, writing it AOQ_1. Then if $AOQ_1(k)$ denotes the Type 1 AOQ resulting from sampling inspection through the end of k years including rectifying inspection to the completed, we have for incoming lot quality, p, the simple relation,

$$AOQ_1(k) = [P_a(1)]^k p = [P_a(k)]p$$

with the usual approximation.

Thus for the values used in Table I, by multiplying the entries in that table by the appropriate fraction defective, one has the Type 1 AOQ's shown in Table II. Approximate values of the average outgoing quality limit (AOQL) for each year are underlined. The decrease in these values year by year is also likely to be reassuring to public utility commissioners.

Table I—Values of $P_a(k)$

p (%)	$P_a(1)$	$P_a(2)$	$P_a(3)$	$P_a(4)$	$P_a(8)$
1	1.000	1.000	1.000	1.000	1.000
2	0.988	0.976	0.964	0.953	0.908
3	0.904	0.817	0.739	0.667	0.445
4	0.717	0.514	0.369	0.264	0.070
5	0.488	0.238	0.116	0.057	0.003
6	0.300	0.090	0.027	0.008	....
7	0.166	0.028	0.005	0.001	....
8	0.084	0.007	0.001	....	....
10	0.021	....	....	....	....
12	0.003	....	....	....	....

But since rectifying inspection is actually to proceed at the rate of one-rth of the lot per year, current or Type 2 AOQ's can be calculated which may be considered more realistic since such quantities, $AOQ_2(k)$, will show the average percent defective of a lot of incoming quality, p, at the end of the k-th year due to rectifying inspection so far completed. Now we have:

$$AOQ_2(1) = P_a\,p + (1 - P_a)\left(1 - \frac{1}{r}\right)p$$

$$AOQ_2(2) = \left[P_a^2 + P_a(1 - P_a)\left(1 - \frac{1}{r}\right) + (1 - P_a)\left(1 - \frac{2}{r}\right)\right]p$$

.....

$$AOQ_2(k) = \left[P_a^k + P_a^{k-1}(1 - P_a)\left(1 - \frac{1}{r}\right) + \ldots + (1 - P_a)\left(1 - \frac{k}{r}\right)\right]p$$

$$= \left[1 - \frac{k}{r} + \frac{P_a(1 - P_a^k)}{r(1 - P_a)}\right]p; \quad (k \leq r)$$

$$AOQ_2(r + k) = \left[P_a^{k+r} + P_a^{k+r-1}(1 - P_a)\left(1 - \frac{1}{r}\right) + \ldots + P_a^{r+1}(1 - P_a)\left(1 - \frac{r-1}{r}\right)\right]p$$

$$= AOQ_2(r)\,P_a^k; \qquad (k = 0, 1, 2, \ldots)$$

For the example used in Tables I and II values of Type 2 AOQ's are shown in Table III.

It may be noted that for $k < r$ there is no Type

Table II—Values of Type 1 AOQ's

p (%)	$AOQ_1(1)$ (%)	$AOQ_1(2)$ (%)	$AOQ_1(3)$ (%)	$AOQ_1(4)$ (%)	$AOQ_1(8)$ (%)
1	1.00	1.00	1.00	1.00	1.00
2	1.98	1.95	1.93	1.91	1.82
3	2.71	2.45	2.22	2.00	1.34
4	2.87	2.06	1.48	1.06	0.28
5	2.44	1.19	0.58	0.28	0.02
6	1.80	0.54	0.16	0.05	...
7	1.16	0.20	0.04	0.01	...
8	0.67	0.06	0.01	...	...
10	0.21	...	...	...	...
12	0.04	...	...	...	...

Table III—Values of Type 2 AOQ's

p (%)	$AOQ_2(1)$ (%)	$AOQ_2(2)$ (%)	$AOQ_2(3)$ (%)	$AOQ_2(4)$ (%)	$AOQ_2(8)$ (%)
1	1.00	1.00	1.00	1.00	1.00
2	1.99	1.98	1.96	1.94	1.85
3	2.93	2.79	2.60	2.35	1.57
4	3.72	3.23	2.60	1.86	0.49
5	4.36	3.41	2.30	1.12	0.06
6	4.95	3.58	2.13	0.64	0.01
7	5.54	3.84	2.10	0.35	...
8	6.17	4.18	2.18	0.18	...
10	7.55	5.05	2.55	0.05	...
12	9.01	6.01	3.01	...	...

2 AOQL; as p increases, $AOQ_2(k)$ tends to $(1 - k/r)p$. But for $k \geq r$, a Type 2 AOQL exists which is always greater than the corresponding Type 1 AOQL but decreasing with k. In Table III, the two AOQL's (underlined) are not much greater than the corresponding ones in Table II. Usually a Type 2 AOQL will either be quite small or not much greater than the corresponding Type 1 AOQL.

IT is likewise possible to calculate the average total inspection (ATI) in two ways. First, at the end of the k-th year, one can compute the average amount of inspection per lot due to sampling and screening of lots rejected in that and previous years including inspection of rejected lots required to complete the screening begun but not yet finished. If this kind of ATI be designated Type 1, and if $ATI_1(k)$ be the Type 1 ATI incurred at the end of the k-th year:

$$ATI_1(1) = n + (N - n)(1 - P_a)$$

$$ATI_1(2) = n + nP_a + (N - n)[1 - P_a + P_a(1 - P_a)]$$

$$ATI_1(k) = n(1 + P_a + \ldots + P_a^{k-1}) + (N - n)(1 - P_a)(1 + P_a + \ldots + P_a^{k-1})$$

$$= (1 - P_a^k)\left(N + \frac{nP_a}{1 - P_a}\right); \qquad (k = 1, 2, \ldots, r, r + 1, \ldots)$$

$ATI_1(k)$ then is the average amount of inspection incurred per lot due to the operation of the plan for the first k years. To find the average total inspection per lot per year for the first k years, $ATI_1(k)$ must be

Table IV—Values of Type 1 ATI's

p (%)	$ATI_1(1)$	$ATI_1(2)$	$ATI_1(3)$	$ATI_1(4)$	$ATI_1(8)$
1	75	150	225	300	600
2	194	387	575	762	1 490
3	1 030	1 960	2 800	3 560	5 930
4	2 880	4 950	6 430	7 500	9 480
5	5 160	7 670	8 900	9 500	10 000
6	7 070	9 130	9 760	9 950	10 000
7	8 350	9 730	9 970	10 000	10 000
8	9 170	9 940	10 000	10 000	10 000
10	9 790	10 000	10 000	10 000	10 000
12	9 970	10 000	10 000	10 000	10 000

divided by k. As k increases, the limiting value of $ATI_1(k)$ is the lot size plus the inspection of samples over the years before the lot was rejected. For our example, values of $ATI_1(k)$ are shown in Table IV.

It is clear from Table IV that over a period of four or more years in the example used, the savings in inspection by use of the sampling plan for lots six percent or more defective will be negligible.

Table V—Values of Type 2 ATI's

p (%)	$ATI_2(1)$	$ATI_2(2)$	$ATI_2(3)$	$ATI_2(4)$	$ATI_2(8)$
1	75	75	75	75	75
2	104	133	162	189	180
3	308	519	706	883	589
4	761	1250	1610	1860	491
5	1320	1920	2220	2360	135
6	1770	2280	2430	2480	20
7	2160	2430	2490	2500	2
8	2300	2480	2500	2500	0
10	2450	2500	2500	2500	0
12	2490	2500	2500	2500	0

Finally we can calculate the ATI per lot that will be performed during the k-th year including the sample taken, if the lot has not been previously rejected, and the portion of the rectifying inspection scheduled for that year if the lot is rejected during that year or in any of the preceding $r - 1$ years. I will call this a Type 2 ATI and designate it by $ATI_2(k)$. We have:

$$ATI_2(1) = n + \left(\frac{N}{r} - n\right)(1 - P_a)$$

$$= nP_a + \frac{N}{r}(1 - P_a); \qquad \left(\frac{N}{r} > n\right)$$

$$ATI_2(2) = P_a\left[nP_a + \frac{N}{r}(1 - P_a)\right] + \frac{N}{r}(1 - P_a)$$

$$= nP_a^2 + \frac{N}{r}(1 - P_a^2)$$

$$ATI_2(k) = nP_a^k + \frac{N}{r}(1 - P_a^k); \qquad (k \leq r)$$

$$ATI_2(r + k) = P_a^k \; ATI_2(r); \qquad (k = 1, 2, \ldots)$$

For our example values of $ATI_2(k)$ are shown in Table V.

Of course these values, which might be called current ATI's are not comparable to the corresponding $ATI_1(k)$'s. In general $\sum_{j=1}^{k} ATI_2(j) < ATI_1(k)$; the difference between an $ATI_1(k)$ and the sum on the left being the average amount of screening inspection per lot yet to be performed due to rejection of the lot in the k-th or a preceding year. The sharp drop in $ATI_2(8)$'s as compared with $ATI_2(4)$'s, especially for higher values of p, is obviously due to the fact that few lots will have escaped a rectifying inspection for eight years with $r = 4$. This table again shows that for practical purposes lots six percent or more defective might as well have been 100 percent inspected at the rate of 2500 per year.

PERHAPS it should be remarked that in the above it is assumed that 100 percent inspected lots will be thoroughly cleaned up and will not be returned to the sampling inspection plan. This is not realistic since I doubt if any public utility commission would agree to this. It is not to be expected that the rectifying inspection will correct all the defective meters in a lot. But neglecting deterioration in use, it seems likely that corrected lots will be less than one percent defective. It is certain that deterioration in use will occur; however, for meters in residential use, for which the sampling inspection plans are proposed, studies seem to show that those manufactured in recent years wear imperceptibly over a period of years well beyond that customarily set for complete inspection of all meters in use.

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BASIC PHILOSOPHIES IN RELIABILITY

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Introduction

THE PROBLEMS of unreliability in complex equipment, today, are very largely management problems. This is true as spite of the fact that reliability failures manifest themselves in technical problems. Experience has frequently demonstrated that the sequential solution of technical problems alone, does not assure ultimate reliability in a product.

Of particular interest are the observations that many commercial products, such as radios, electric motors, refrigerators and others, designed and manufactured many years ago, when reliability, as such, received no special attention, are still in operation today with remarkably little maintenance.

An analysis of the underlying reasons will show, in general, that limitations on size and weight of some of these products were either moderate or non-existent. In some cases the products were grossly overdesigned with enormous factors of safety for their applications. In other cases, the products had evolved through gradual design changes over many years, accumulating vast amounts of experience and special knowledge. Such considerations provide some of the most effective safeguards against unreliability.

The automobile industry, with its annual revolutions in design and manufacturing methods, provides a considerably lower measure of reliability to the consumer. The huge factors of safety (strength *vs.* stress), unlimited size and weight allowances, long experience with a fixed design or gradual evolution of a new design are not the general rule.

We are particularly concerned here with the areas in which high reliability in a relatively new and complex product is an essential part of the product specification. Size, weight and cost may be severely restricted. Large factors of safety are just not possible. These are areas in which experience has not yet had time to mature.

The rapid achievement of reliability objectives in such areas can be assured only through the implementation of a comprehensive reliability program combining essential technical and management techniques — a program which spells out in detail the steps which an organization must follow, from the initial analysis of the reliability requirements of a proposed piece of equipment through to the collection and effective use of failure data—a program which realistically budgets each of the steps and provides for the measurement of progress as a means of monitoring and evaluating each step—a program which readily inspires confidence that it will work through its inherent logic, simplicity and completeness.

Historical Background

It is somewhat unique in management history to find that a program of this kind has been evolved

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with major government participation and stimulation. In this particular case, of course, our military has suffered badly by the lack of such a program in the past and has been the only customer to ask, specifically, for unusually high reliability in extremely complex equipment.

In the last two years, the Department of Defense has formally adopted policies and basic philosophy with regard to the reliability of military equipment. A considerable number of documents — expanding on management and technical aspects of a reliability program, on detailed reliability specifications, on controls, on test specifications and criteria for proof of compliance — have recently been issued by individual agencies of the Department of Defense. These documents lay the foundation for realistic and practicable comprehensive reliability programs.

To the uninitiated, all this may appear very sudden. However, this apparently sudden rash of DOD reliability documents and specifications is merely the culmination of about ten years of background studies and activities, by specialists in both government and industry, which came to a climax in 1957 with the publication of a rather comprehensive report by the Advisory Group on Reliability of Electronic Equipment (AGREE) under the Office of the Assistant Secretary of Defense. This work actually began in 1950 with an *ad hoc* group formed within the Department of Defense to make a general survey of the reliability problem. After it had formulated a broad set of recommendations in 1951, the group was re-established on a continuous basis in 1952 and finally reorganized again in 1955 into the group now known as AGREE. The final report is divided into the work of nine task groups which worked towards a set of specific objectives aimed at getting answers to a broad spectrum of reliability questions.

Altogether, the report formalizes a philosophy, a set of definitions, a group of technical and statistical procedures and a number of organizational and management principles which are considered essential for the understanding and achievement of reliability objectives. The various reliability documents and specifications which have been issued are, almost universally, based on the AGREE report. Following one of the AGREE recommendations an *ad hoc* study group under the Office of the Director of Defense Research and Engineering and the Office of the Assistant Secretary of Defense, Supply and Logistics, has very recently issued a report on Parts Specification Management for Reliability.

The emphasis to date has been predominantly on electronic equipment for the obvious reason that this is where the problems and effects of unreliability have been most severe. In response to the problem of reliability training in this area, a joint committee of the PGRQC of IRE and the Electronics Division of ASQC have developed a Reliability Training Text, based on AGREE recommendations, which has been the basis of a series of Reliability Training Conferences scheduled throughout the country and administered by this committee.

Reliability Yardsticks

The word "reliability" is frequently used, as has been true so far in this discussion, as a general concept. It is also used as a quantitative measure and in this sense can be defined as the probability that the equipment will perform a specified function under given conditions for a specified period of time without failure. Inherent Reliability, Use Reliability, Operational Reliability, etc. are more explicit forms of the same measure. We shall avoid confusion between the concept and the quantitative measure in this discussion by using "Probability of Survival," P_s, to denote the quantitative measure.

The purpose of and need for particular equipment actually determines the kind of reliability measure which is most meaningful and most useful. Probability of Survival and Mean Time To Failure, MTTF, are particularly appropriate for missiles and other one shot devices. For other systems which require no-failure operation over repeated usages and for systems which require a low failure rate over continued use, Mean Time Between Failure, MTBF, is commonly used. In such systems, the MTTF and the MTBF are quantitatively identical.

Availability is used in situations in which minimum down time is most important. Commercial computers would fall into this category. Availability can be defined as the probability that the equipment will be operational at any time or as a ratio of total operating time to total operating time plus total down time.

There are situations in which the maintenance or repair time itself is most critical. In such cases, the Mean Time To Repair and Maintainability are appropriate. Maintainability can be defined as the probability that a failure will be repaired in less than a specified time when it occurs. It does not reflect the frequency of failure as does availability.

Failure Rate is the commonly used measure of reliability of basic parts.

The definition of failure is almost always critical in applying any of these measures. There is a considerable difference between equipments which perform slightly outside of specified tolerances as compared to those which have complete breakdowns. Are both situations to be defined as failures? If operational conditions or maintenance requirements are poorly specified, the identification of a true failure may be sticky business.

The element of cost becomes an important consideration in the specification of one or more of the above measures for an equipment. High MTBF and high maintainability are frequently required, but costs sometimes necessitate a compromise or trade-off of one in favor of the other. Actual experience in the Air Force on a receiver, purchased at two different levels of MTBF, indicate that the vastly increased cost of maintenance on the lower MTBF version made it several times more costly than the other over a given period of time. There are some who argue that lower mean life, supplemented by redundancy and high maintainability, provide the most economic approach.

Prevailing Philosophy

In the prevailing reliability philosophy, several fundamental premises stand out prominently.

The first is that reliability is basically a design parameter. The backbone of equipment reliability is determined in the design stage. The full potential is established here.

Failure analysis and reliability prediction, design reviews, trade-offs, derating of parts and redundancy are essential techniques

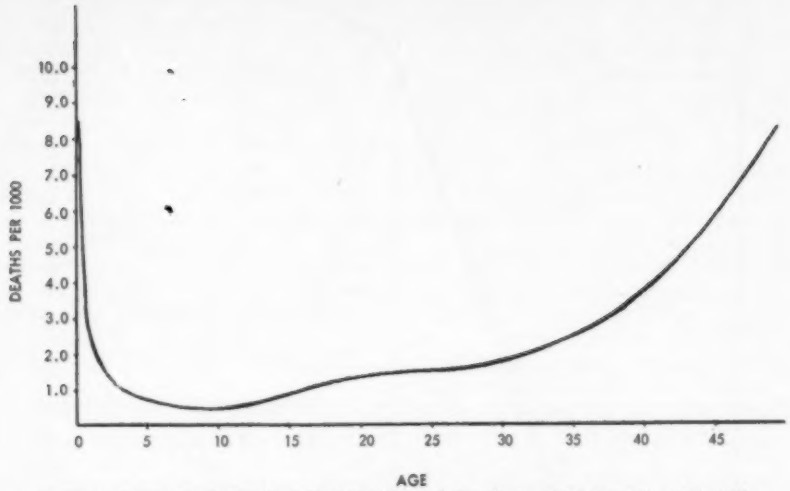

Figure 1—Human Population Mortality Rate Curve, United States Total Population 1949-1951

to aid the design engineer in achieving his objectives. Specialists in these techniques, in their management aspects and in related concepts and skills are the new Reliability Engineers. The design engineer requires the cooperative efforts and assistance of specialists in parts, structures, environmental stresses, manufacturing processes and capabilities, packaging and transportation, human engineering and any others whose technical knowledge and experience can be useful in the anticipation and elimination of potential weaknesses and modes of failure, during the earliest stages of design. The coordination of such efforts has been assigned to the Reliability Engineer.

It requires an equally monumental task of coordinated efforts to translate this design with its potential and predicted reliability into operational equipment with an inherent reliability which approaches the design potential. Quality engineers, product engineers, manufacturing specialists, environmental test engineers, field engineers and others play a vital part in attaining the highest standards of manufacturing quality, in assuring the required reliability in purchased parts and in providing feedback information for design improvements from the earliest stages of hardware evaluation and prototype activity to the ultimate stages of field use of equipment.

An essential feature of the reliability philosophy is the continued reliability prediction at each successive design stage throughout the design phase. The techniques of failure analysis and reliability, crude as they be initially, provide the design engineer with an estimate of the reliability status of the design, with a better understanding of the areas which require advancement in the state of the art, with a comparative measure of reliability improvement which can be achieved through design changes, trade-offs, redundancies, etc. At the same time, these predictions provide a basis for setting reasonable reliability specifications on objectives on portions of the total system and particularly on sub-contracted portions and purchased parts.

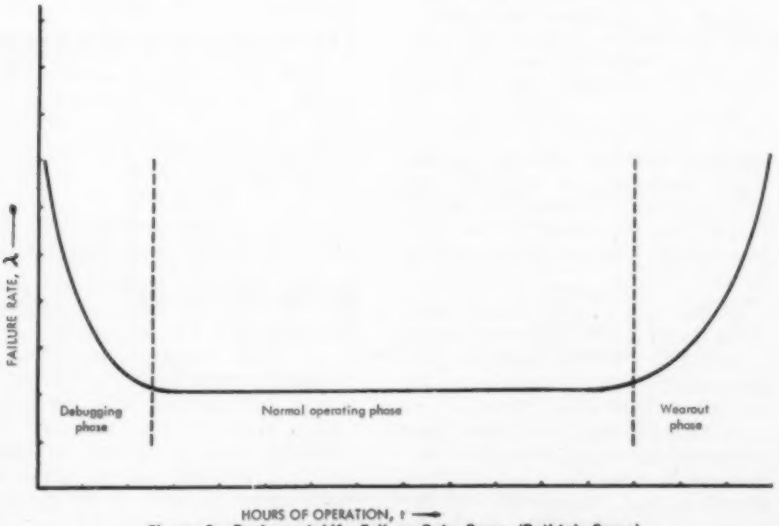

Figure 2—Equipment Life Failure Rate Curve (Bathtub Curve)

Underlying Concepts

Underlying the reliability prediction technique is a very basic premise which among other things may be called the constant failure rate concept. This is not too difficult to accept once we take a look at some recent data on the mortality rates of the population of the United States in Fig. 1. We see a high mortality rate for babies up to the age of two or three; followed by a relatively constant mortality rate (under two deaths per 1000 to the age of 25 to 30; and a rapidly increasing mortality rate beyond. It would be interesting to conjecture whether the slight rise in mortality rate at early maturity or adolescense reflects the new found freedom of the individual with all its dangers and responsibilities such as may be introduced by the automobile.

There has been an abundance of experience to indicate that the failure rates of complex equipments and of electronic parts follow a similar curve when plotted against hours of use. We can divide the curve, generally called the "bathtub" curve, into three sections as idealized in Fig. 2. The first section is the infant mortality or debugging phase, in which failure can be attributed primarily to defective or marginal parts and to manufacturing deficiencies in general. The center section is alternatively called the constant failure rate portion, the Poisson portion, the random failure portion, or the normal operating portion. The third section is the wearout portion during which the actual wear accumulated through use or degradation through time is manifested through an increasing failure rate.

As new equipment goes through the debugging phase, its failure rate will diminish until the constant failure rate phase is reached. During this phase failures occur at random times and at a relatively

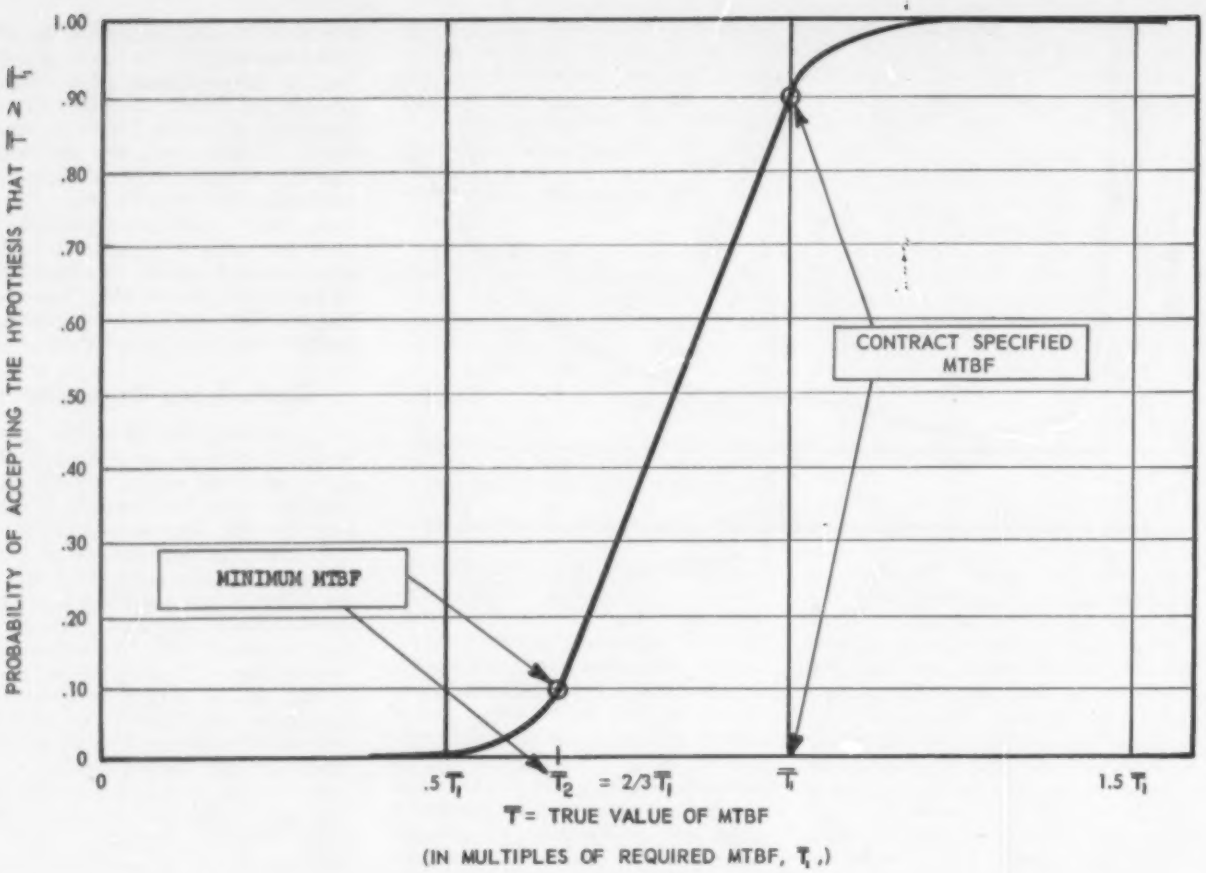

Figure 3—OC Curve for Sequential Sampling Plan

constant rate with relatively little or no signs of wear. When actual wearout and degradation of parts starts to increase, equipment can be rejuvenated through a planned program of preventative maintenance and replacement of worn or degraded elements, extending the normal operating portion of its life for an additional period of time. When such maintenance is uneconomical or otherwise impossible, then the equipment has reached the end of its useful life.

Over the years medical science has found the means to shorten the infant mortality cycle of man and to reduce the mortality curve within that cycle, and to lower the Poisson mortality rate and to extend man's longevity. Design, engineering and manufacturing sciences are similarly finding the means to improve the "bathtub" curve of equipment.

It is the height of the curve, the failure rate during the constant failure rate portion of equipment, which completely determines the equipment reliability. The length of this portion of life is not considered in the reliability measure in that it is expected to go beyond the expected need for the equipment or to be extended by preventative maintenance to cover the length of need.

It may be possible to justify the random or constant failure rate phenomenon in a variety of ways. One which is particularly attractive sets the premise that only one type or source of part has a threshold of failure, higher or lower for some types or sources than others. In the course of time, environmental and internal stresses which the equipment containing the part endures will, at random times, cumulate or pile up sufficiently high to reach or exceed the failure threshold of the part. The effect would be an equipment failure.

In this light, failure rates for a given part may be reduced by increasing its failure threshold by increasing its reliability or by reducing the stresses placed on the part through improved shock and vibration mounting, improved heat dissipation provisions or derating practices, etc. Essentially we are speaking of an increase in the factor of safety, which is the common practice in mechanical structures and devices. This practice has not been rigorously followed in the case of complex electronic equipment. One of the reasons may be that the development of improved electronic parts has not kept pace with the extreme revolution of size and weight requirements on total equipments.

The Exponential Life Curve

Under the constant failure rate system, the Probability of Survival, P_s, expressed as a function of time, must follow the exponential life curve:

$$P_s = e^{-\lambda t}$$

where λ is the constant failure rate and t is the time of operation.

This follows readily through logic as well as through mathematical proof. For any given time, t, the life function provides a bridge between P_s and λ. Furthermore, interpreting the constant failure rate, λ, as a number of failures for some increment of time or life, the reciprocal of λ gives us the number of hours of life for the specified number of failures. This

leads to an average number of hrs. of life per failure, which is an expression of mean life, m, MTTF, or MTBF. Using m as a most general expression for mean life, we now have relationships between λ, m and P_s which make them completely interchangeable. Failure rates of parts are additive under the constant failure rate system and under assumptions of independence and can thus be combined to give predicted failure rates for overall systems. These, in turn, are translated into the mean life or P_s parameters.

Statistical Applications

Proof of meeting a specified reliability figure can now become proof of meeting a specified failure rate with an appended time requirement. With a constant failure rate and random occurrence of failures, the number of failures in any specified increment of time must theoretically follow the Poisson distribution. We call upon well known sampling theory, based on the Poisson distribution, to set up our reliability tests and acceptance criteria. Hours of operation become the basic sampling units with numbers of failures as the measured variable. The Operating Characteristic curve is plotted against the parameter, λ, or its reciprocal, m.

Current military specifications in contracts dealing with reliability append a 90 percent confidence factor to the specified reliability measure given. This, in fact, is nothing more than a specification of the old Dodge-Romig LTPD or the ten percent point on the OC curve. An OC curve, taken from the Air Force document AMCP 74-1, is shown in Fig. 3. It is drawn against mean life expressed in multiples of required MTBF. For good reason, the sampling plans specified are the Wald sequential plans. The number of test hours can become oppressively large for a specified OC curve and the sequential plan will require a minimum of test time on the average. This is an ideal area of application for the long known and seldom used sequential plans.

Theoretically, assuming that all equipments manufactured have the same reliability, it would be possible to accumulate the required number of test hours all on one equipment, repairing each failure as it occurs and continuing the test or on a large number of equipments, each tested for a fraction of the required number of test hours. In practice however, this is too strong an assumption to make. The AGREE report and ensuing documents specify a continuous production sampling plan, shown in Fig. 4, by which production units are qualified to go onto a monthly sampling plan. Each of the equipments tested under this plan is submitted as part of the specified group to the sequential reliability test. The plan is devised to give 90 percent assurance that there are fewer than ten percent of the production equipments which do not meet the reliability requirements. Its OC curve is shown in Fig. 5. When production has been qualified to go onto a monthly sampling plan, the sample size of equipments to be submitted to sequential reliability testing each month is dependent on the monthly production rate and on the specified MTBF and computed in such a way as to give a minimum of the total of production time and reliability test time. The sample at all times must be a minimum of four equipments and Fig. 6 illustrates a selection of OC curves for some monthly sample sizes.

In all, we have here a most remarkable combination of continuous sampling procedures, minimizing procedures, single sampling

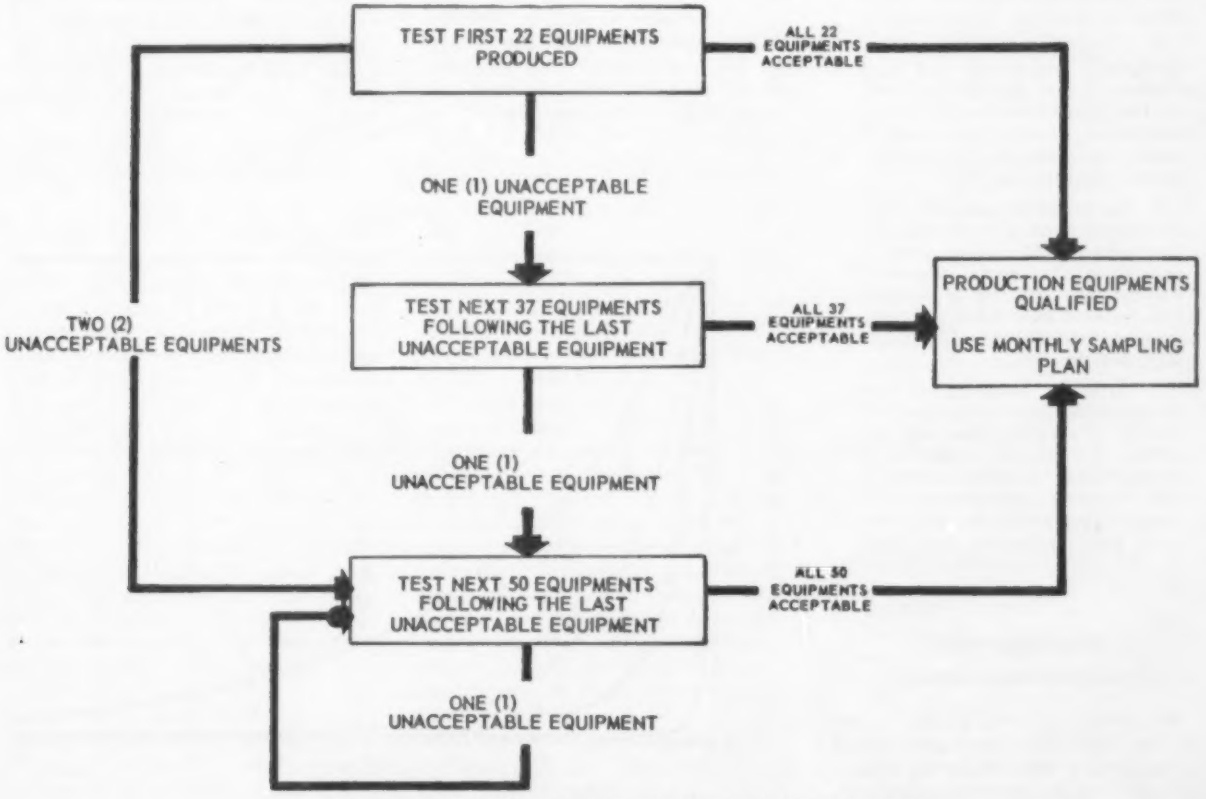
TEST FIRST 22 EQUIPMENTS PRODUCED
ALL 22 EQUIPMENTS ACCEPTABLE
ONE (1) UNACCEPTABLE EQUIPMENT
TEST NEXT 37 EQUIPMENTS FOLLOWING THE LAST UNACCEPTABLE EQUIPMENT
ALL 37 EQUIPMENTS ACCEPTABLE
PRODUCTION EQUIPMENTS QUALIFIED
USE MONTHLY SAMPLING PLAN
TWO (2) UNACCEPTABLE EQUIPMENTS
ONE (1) UNACCEPTABLE EQUIPMENT
TEST NEXT 50 EQUIPMENTS FOLLOWING THE LAST UNACCEPTABLE EQUIPMENT
ALL 50 EQUIPMENTS ACCEPTABLE
ONE (1) UNACCEPTABLE EQUIPMENT

Figure 4—Flow Chart for Attribute Sampling Plan for Production Qualification

plans and sequential sampling plans.

Other Essential Practices

To complete the picture of technical practices, principles and techniques which are needed, we must add some which are more or less familiar to the quality engineer:

1. Statistical tolerancing which will allow for unavoidable drift in design parameters and for wide ranges of specified environments.

2. Vendor evaluation, qualification and rating as a means of assuring maximum competence in sources of supply.

3. Parts selection, testing and qualification. Long established standards and specifications of quality for parts have become obsolete in the face of the newer reliability requirements. Failure rate determinations and reliability conformance testing are expensive and time consuming ingredients.

4. Standardization and calibration of test equipment which is sometimes as complex and unreliable as the manufactured equipments themselves.

5. Environmental testing in which the need to reasonably simulate end-use environments and conditions present some very formidable problems.

6. Comprehensive failure and deficiency reporting and data analysis from the earliest tests on hardware to actual field experience provide an essential means of correcting design and manufacturing deficiencies.

7. Failed parts analysis as a vital means of determining the true causes of failure and of providing the parts manufacturers with information which can be used as a basis for eliminating manufacturing and design deficiencies.

8. Detailed analyses of expected equipment usage and expected environmental and internal stresses are essential in establishing realistic detailed specifications, tolerances, reliability requirements, maintenance and packaging provisions at the very beginning of the project.

Management Considerations

We have discussed briefly many of the technical elements which comprise the basic building blocks of the reliability structure. To these must be added the management elements which provide the overall plan, the personnel, estimates of time and cost, the financing, the scheduling, control and supervision, modifications in plans to improve them as necessary. We must not underestimate the importance of the management element which provides the cohesive force by which all other basic elements are combined and made into an effective unit to achieve the ultimate objective. As is true for any really effective program, every essential element and no unnecessary element must be present.

Education on all levels of personnel is of major importance — from the floor sweeper who conscientiously picks a transistor off the floor and puts it back in a bin — to the top management executive who must approve the costs of an effective reliability program and withstand the pressures for tight delivery promises which would abort the reliability effort.

Whatever arguments may be offered in opposition to any part or parts of the current reliability philosophy which have been discussed here, three very relevent facts stand out sharply:

1. It provides a real, concrete, organized course of action which

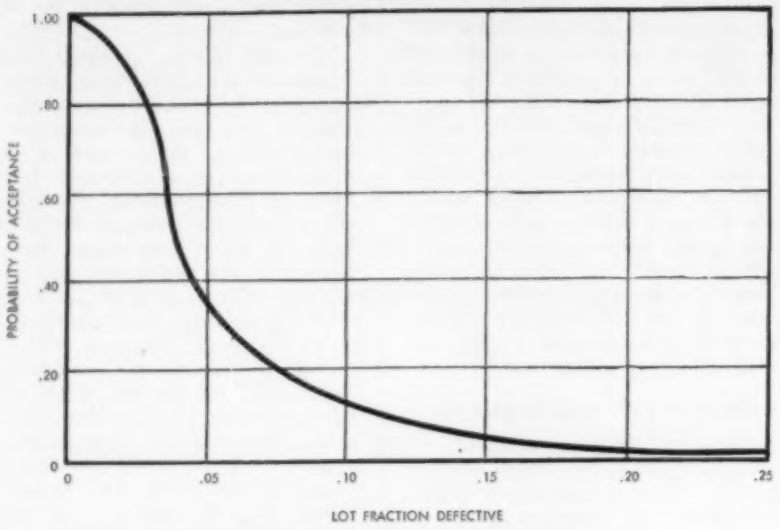

Figure 5—OC Curve for Continuous Sampling Plan

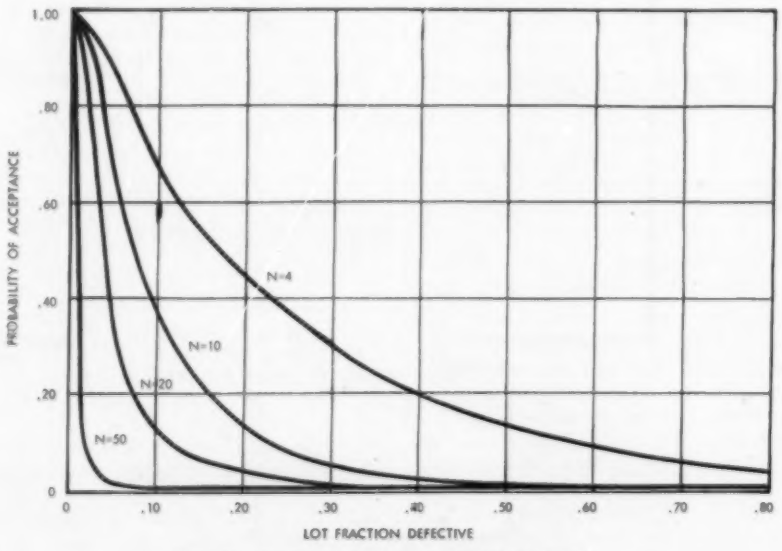

Figure 6—OC Curves for Monthly Production Samples

can eliminate the usual trial and error as an initial means of approaching a complex situation.

2. The experiences of companies that have adopted this reliability philosophy of a comprehensive or system reliability approach have proved its effectiveness.

3. The Department of Defense has adopted and encourages this philosophy as the one by which its high reliability needs can be filled in the design, development and production of complex equipment.

Conflicting Philosophy

We should not, however, close our eyes to any fundamental weakness in a philosophy even though its current application has paid off well and can be expected to pay off even more handsomely in the near future. It is only through a realistic recognition of the weaknesses in the current reliability approach that we can hope to overcome them.

One such area, and this is a personal point of view, is the fantastic expenditure of time and effort which is required on parts testing to establish reasonably precise estimates of the failure rates of parts under the variety of stress conditions to which such parts may be subjected. Reliability prediction, from the earliest stages of design, is one of the cornerstones of the current philosophy and requires that such failure rates be determined.

In essence, this is not the kind of dynamic expenditure of our time and manpower resources which will provide the reliability breakthroughs of the future. If a reasonable fraction of this parts testing effort would be devoted to statistically engineered investigations and experiments, designed to optimize part designs and manufacturing processes and equipment designs as well, then failure rates would be reduced and real progress would be made in preparing the way for parts and equipment reliabilities which are not now even considered feasible. We know that real progress of this kind is made only when it has been laid out as a prime and specific objective.

Our engineers must be more heavily motivated to the objectives of improvement and optimization and must learn through more extensive experience to use the statistical tools which are now available to assist them in this direction.

In short, there is a conflict between the efforts to *measure* part failure rates and the efforts to work for the *reduction* of part failure rates. The former demands so much of the available resources that it must detract from the latter.

The current philosophy will, without doubt, provide the handles by which huge gains in reliability will be made. Reliability achievements have not been consistent with our scientific, engineering and manufacturing capabilities, but will move ahead quickly to gain this consistency. From that point, however, we will be limited by our capabilities which must not be neglected until that time.

Reliability vs. Quality

There are quality engineers who have taken the stand that reliability is nothing more than quality with the added dimension of time. To a large extent this reflects the same kind of lack of understanding which has been shown by design engineers who picture the quality control function as an inspection operation. Both are uninformed, unconstructive and discordant points of view.

The reliability philosophy which we've discussed places a heavy responsibility for reliability on the design engineer and requires of him a high degree of creativity. However, a top notch quality engineering and assurance function is absolutely essential if the inherent reliability objectives are to be achieved in the operational equipment. The total quality function with all its organizational, management and technical skills and capabilities must be brought to full effectiveness.

This is absolutely necessary but not sufficient. Even best quality engineered and manufactured product can have miserably poor reliability if it has not been properly designed to operate under the intended environmental stresses. Unreliability studies on several types of complex equipment have shown that failures due to inadequate design significantly outweigh failures due to manufacturing deficiency in a ratio of about two to one.

We must have design oriented specialists on one hand and manufacturing oriented specialists on the other who can anticipate the modes of potential failure and the degrees of unreliability attributable to design and to manufacturing deficiencies and can recommend preventative measures in their respective areas.

The achievement of our highest reliability and quality potential is dependent on the kind of totally organized effort which we've discussed here and on mutual and sympathetic understanding and cooperation between design, manufacturing and quality personnel.

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Management Planning and Control For an Effective Quality Function

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The quality function is rapidly assuming its logical position as a very necessary technical service associated with the successful manufacture of a product.

It would appear that if it is to continue to play its part in the release of products that are competitive—both in terms of price and quality—a dynamic approach must be taken in planning the quality function itself. Many of the management techniques related to the design of a manufacturing function can also be used in connection with the design of a quality function. While the applications may not always be apparent, they are certainly appropriate.

We generally associate input of material and man hours and output of a product with manufacturing. Similar criteria may be applied to a quality function.

In this case, input becomes a group of actions classed as manpower assigned to inspection or auditing, and manpower allocated to such efforts as quality engineering and laboratory support. In addition, input is defined in terms of specifications and procedures.

Output becomes identified with the data generated in the various process and assembly control situations and also that data generated in connection with final performance of a product. This product is in the hands of a customer or in the hands of another manufacturer, who in this case is the user.

With this information as background, it seems logical to apply such criteria to the actual organization of a quality control function, area by area, in order that we may test out the inputs and outputs and thereby design the quality control function, not from a service standpoint, but from a management standpoint.

In reviewing that area normally known as purchasers quality control, we might expect the following *input items*:

The incoming material

Quality specifications which have been placed in the hands of suppliers, identifying the in-plant audit and sampling techniques which prevail
Inspection personnel

In terms of *output*, we would expect to see supplier conformance reporting. This in turn notifies quality control of part and supplier status. This information is also fed to the purchases function in order that they have a measure of their effectiveness in selecting adequate suppliers. Additional output keeps the quality manager advised in terms of jobs per person, cost per job and inspection efficiency in order that effective control of manpower may be exercised.

In the area of manufacturing or processing, we would expect the following *input*:

Process controls—These may be of the variety normally associated with a machining effort or with the handling of raw materials. These inputs can be considered in terms of complex chemical preparation and/or assembly, such as one might find associated with transistors, ferrite cores, etc.

The *output* of such data indicating overall quality levels, trends by department, and trends by operator or by operation pinpoint corrective action where required.

Another *output* is the measurement of scrap and rework. This data may be used primarily as; a) a test of effectiveness of process controls, b) manufacturing efficiency; i.e., training, layout, material handling, etc., c) tooling and machine capability. Effective work simplification or work measurement programs are necessarily dependent on precise quality measurement programs in order that true efficiency in terms of product quality might be established. This is fast becoming a very real test of quality control data as a powerful output necessary to implement management controls.

A third area associated with assembly and final test of a product defines the following inputs:

Assembly process controls
Component analysis programs
Audit and inspection personnel

Outputs are:

Defect data on components and systems directly usable by manufacturing, manufacturing engineering and quality control for corrective action, and
Collection and analysis of product performance in customers' environment. By establishing common coding between in-plant analysis and field analysis, the corrective action cycle can be considerably shortened. Correlation between in-plant and field data is significantly improved.

So far, my comments have been associated primarily with those phases of the quality function which are directly connected with the product itself; namely, purchase quality, component quality and systems quality. You will note that the breakdown has been on a product basis rather than on a service basis.

In addition to these areas, management has recognized the need for a cohesive force which shall recognize and generate the necessary functional policies to assure overall direction to the quality function. This direction can very reasonably be specified as a quality assurance activity and may embrace the following:

I. Quality Engineering—This area logically associates itself with four well-defined responsibilities:
   a. Pre-release: Concern here is one of working with engineering in order to get a better understanding of new products in the pre-release

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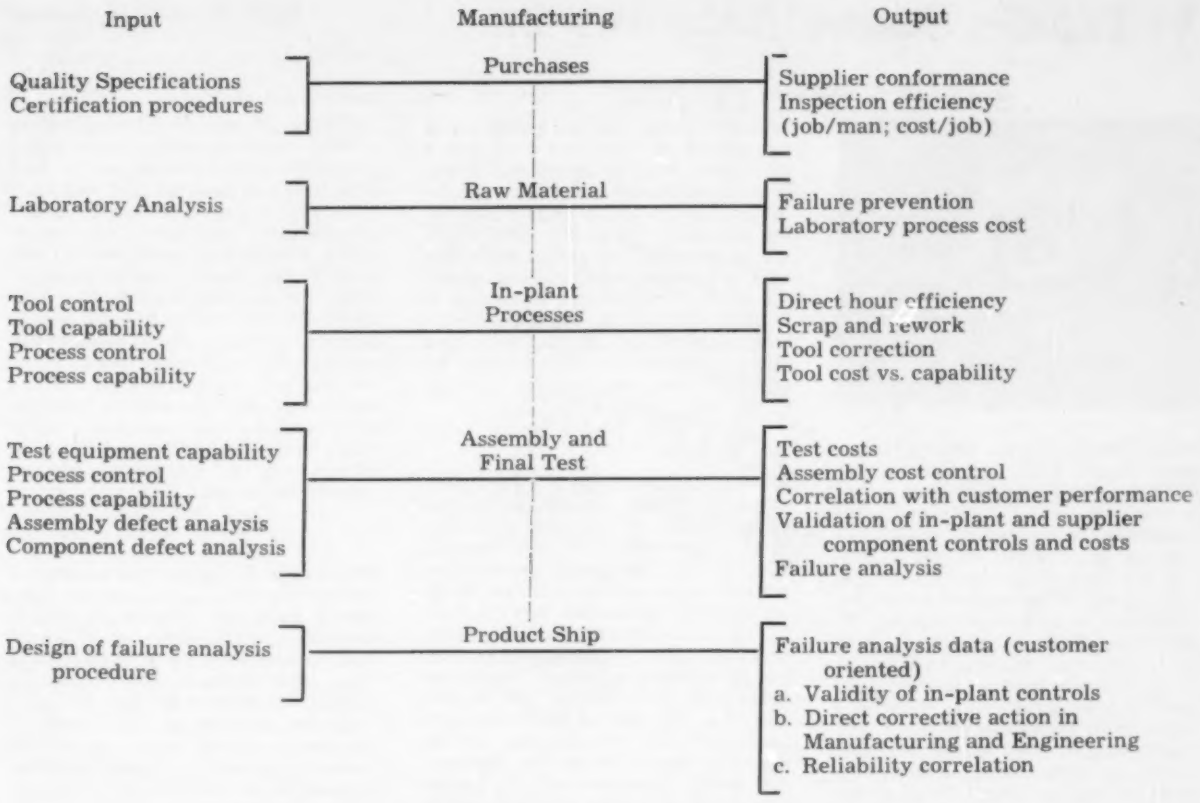

Figure 1—Design of Quality Control Function from a Management Standpoint

stages. This provides engineering with a very direct path for knowledge and experience based on present product performance and makes available to engineering accurate data which they may rely on to guide study programs for future products. Component and system reliability requirements as related to manufacturing facilities are recognized and defined.

b. Component Quality Engineering: This area is concerned with supplier approval activities and in-plant process controls and test equipment normally associated with component manufacture.

c. Systems Quality: Concerns itself with unit and systems testing and test equipment involved. Compatibility between in-plant and customer is constantly evaluated.

d. Methodology: Here is an effort which, on a statistical basis, provides the various quality engineering areas with sufficient strength to develop sound specifications and assistance in the design of experiments in either engineering or manufacturing. It provides mathematical simulation for either product or test equipment studies and where necessary programming backup in data reduction techniques in connection with the handling of daily data generated either by inspection personnel or automated means.

II. Quality Laboratory—Dependent on product requirements, this area provides mechanical, chemical, and electrical analysis and standardizing services affecting incoming material, current problems in manufacturing, and analysis of field situations.

III. Tool and Gage—In order to retain a consistent approach, management-wise, it is not unreasonable to believe that tool and gage may be associated with an assurance activity rather than the actual control of a product.

As can be seen in analyzing the assurance area, the major input is one of technical support and ideas—the output in this case, particularly in the areas of quality engineering—consists primarily of the technical controls, specifications and procedures designed for implementation by the line quality departments.

However, just as important is the conversion to savings which may be directly attributed to the efforts of this group. For example, a dollar sign may be placed on the effectiveness of a quality specification or change of an assembly in-process control. This becomes the output whereby the effectiveness of the group is measured. Simulation tests regarding a piece of test equipment may well influence its design or possibly recommend its removal, therefore, resulting in effects on the product, either internal or purchased, which again may be measured in terms of dollars.

Considering an analysis of this type, the quality function takes on more of the aspects of an organization which is designed for the specific purpose of product quality control and inherent in the design is the means for measuring the effectiveness of the function. Basic to the quality organization is a statement of philosophy with regard to the kind of support manufacturing management can expect from the quality manager. A clear picture of the quality effort in terms of supplier and in-plant operations oriented to the customers' requirements assures the manufacturing manager of his "plant capability."

What's New?

ROY A. WYLIE, *Editor*

901—Millitest Corp., Rotary Index Head, Model THM 101 is an accurate indexing device designed to set or read mechanical shaft angles of rotary electro mechanical equipment such as potentiometers and synchros, and is ideally suited for inspection use by inexperienced operators. It consists of a vertical mounted index wheel with precision gear teeth on its periphery engaged by a quick-acting plunger mating gear-segment pawl. An integral shaft is coupled to the shaft of the device under test. Positioning in steps of one half of a degree is made to an accuracy of three seconds of arc. With pawl engaged at any one half of a degree position a micrometer advance of the pawl block assembly permits further accurate positioning in 30 second steps. An operator can scan the output of the device under test continuously or in any angular increments without extensive operator experience or judgment. Quick acting holding clamps, chucks, and adapters permits rapid testing of a wide variety and sizes of devices.

* * *

902—Boonshaft and Fuchs, Inc. has a desk top analog computer for determining the mean and standard deviation. It requires no adjustment during regular use, can accept up to ten classes, 99 items per class, and a maximum total entry of 600 items. It is called Statistic. Accuracy of the Statistic is 0.2 of the class width for the mean and 0.2 of the class width for the standard deviation and readings are instantaneous following entry of the data into the keyboard. It reduces a 30 minute calculation by a trained machine operator to a five minute operation performance by anyone. Power required is 110 or 220 v, 60 cps.

* * *

903—A precision, wide-range picoammeter with exceptionally fast speed of response and negligible zero drift is now available from General Electric Co. Designed for exacting nuclear applications such as measurement of the output current from a radiation-detecting ion chamber, this high-gain, feedback electrometer has an accuracy of better than three percent of full-scale at all outputs (0-1 ma, 0-10 mv, 0-10v). Dynamic range of the picoammeter is ten decades, from 10^{-12} to 10^{-3} amperes, full scale. Nineteen current ranges are provided by the selector switch. Input current is indicated on a long-scale panel meter. A speed of response of less than one millisecond to 64 percent of final value at 10^{-9} to 10^{-3} amperes is possible with external circuit capacity up to 2.000 picofarads. Zero drift is less than 0.25 percent of full scale at all times. No zero drift control is provided, as adjustments are not necessary. A trip circuit, which operates when a preset point on any scale is exceeded, can be adjusted to any point between 10 percent and 100 percent of scale. Although designed primarily for monitoring nuclear power reactor operation and for unattended radiation monitoring, the picoammeter also may be utilized for biophysical current measurements, mass spectrometry current measurements, and other applications. Its fast response, even with a long input cable, makes it especially suitable as a reactor safety amplifier in a reactor control system. For special remote applications, the picoammeter can be factory-modified for use with servo-operated switches which permit it to be located several miles from a read-out station. Rapid response of the new instrument, as well as freedom from drift, is achieved by a wide band, direct-coupled amplifier stabilized by a vibrating-reed, ac coupled amplifier.

* * *

904—Leeds & Northrup announces a completely new 4393 Six-Dial Universal Ratio Set for use by standardizing laboratories to calibrate such instruments as the L&N 7553 Type K-3 Potentiometer and the 4232-B Wheatstone Bridge. It is also used for the precise calibration of resistance standards and odd-valued resistors, in resistor manufacturing as well as in standardizing laboratories. To provide the highest possible accuracy all resistors are aged for three months or more and enclosed in a thermal equalizing chamber so that thermal emfs are practically non-existant. The metal box is lined to provide additional shielding. Electro-static shielding, to minimize errors due to leakage, is provided by the metal top plate and box. High quality silver alloy switches, of a type which have shown negligible change in contact resistance after several million operations, are used in all critical decades. The unit ranges are $20 \times 100 + 10(10 + 1 + 0.1 + 0.01 + 0.001)$ ohm, for a total resistance of 2111.11 ohms. The limit of error at 25 C is 0.002 percent for dial changes of 100 ohms or more; below 100 ohms, accuracy of reading is within two steps on the 0.001 dial. The instrument is housed in a gray vinyl-covered metal case with cover.

* * *

911—A new 14 inch screen Optical Comparator and Measuring Machine (Jones & Lamson Model FC-14ER) is particularly applicable to the inspection of such parts as lead screws, die bodies, castings & forgings, large circuit boards, etc. The work table is 32 inches long, 8 inches wide and is supported on two heavy duty columns having 10 pitch hardened and ground lead screws. This rugged double spindle construction provides extra stability for motion of large heavy work pieces, both laterally and vertically. Measurement to great

Product Maintainability Working Seminar

The Electronics Division, ASQC, will sponsor a Product Maintainability Working Seminar Oct. 24-25 at the Sheraton Hotel, Philadelphia, Pa.

Topics include specifying maintainability; effects of human factors on maintainability; systems level trade offs—reliability vs. maintainability vs. availability; choosing degrees of automaticity in maintainability; designing for maintainability; measurement and demonstration of maintainability; predicting maintenance time; "throw away" maintenance; pricing and costing for maintenance, and organization for effective maintenance.

The ultimate aim of the Seminar is to attain firm concepts in the above mentioned areas by promoting the exchange of ideas through the individual participation of attendees representing varied products and interests—both commercial and military.

Registration will be limited. For additional information, contact B. W. Marguglio, The Martin Company, Mail No. 2000, Baltimore 3, Maryland.

accuracy is assured. The machine is equipped with the Jones & Lamson Telecentric Optical System which provides projection lenses that are matched and pre-set for exact rated magnification on master optical benches. No adjustments are necessary when changing magnifications. Features available with this model include: electronic variable speed power elevation; variable light intensity control; six-position automatic indexing lens selector; normal reflection unit; tracing attachment and vertical illumination and staging equipment.

* * *

905—Interference filters for precision spectral analysis now are being marketed in boxed sets, individually calibrated by Optics Technology, Inc., 248 Harbor Boulevard, Belmont, Calif. The Spectracoat filters are selected to isolate visible spectrum wavelengths important in laboratory and industrial work. Each set contains ten interference filters covering the range from 404 to 706 millimicrons (K to Ba lines), four neutral density filters and one continuously-variable wedge filter covering the 400-750 millicron range. The filters are of rugged construction, impervious to fumes, water and oil. Also available from Optics Technology to meet special requirements is an infra-red spectrum set covering from the near infra-red through the lead sulphide region (about 0.8-2.7 microns), and filters and band passes in the eight to 30 micron range.

* * *

912—H. H. Scott, Inc. announces a new exceptionally lightweight sound meter. Measuring but 2 by 3 by 6 inches, the new Model 450 can be held in the palm of one hand. It weighs only two pounds, and is operated on an ordinary 22.5 volt battery with operating life of 30 hours. The meter has an exceptionally wide range of operation—from 35.-142 db sound level range and a 40-8000 cps response. This rugged completely transistorized meter comes in a heavy gauge aluminum case. It has a Rochelle salt diaphragm-type microphone. There is a direct reading scale minimizing chance of reading errors. It has a full one-year parts-and-labor guarantee. This meter was specifically designed to the new ASA Standard A, B, and C weightings. The amplifier is stabilized against voltage and temperature changes. This new meter will be extremely useful to safety engineers, personnel managers, acoustical contractors, architects, industrial hygienists, police departments, hospitals and clinics. It can be used for surveying noisy areas, for estimating the possibility of hearing damage. It will measure noise levels in any location —indoors or out. The new 450 can measure dispersion pattern and level of sound from public address systems

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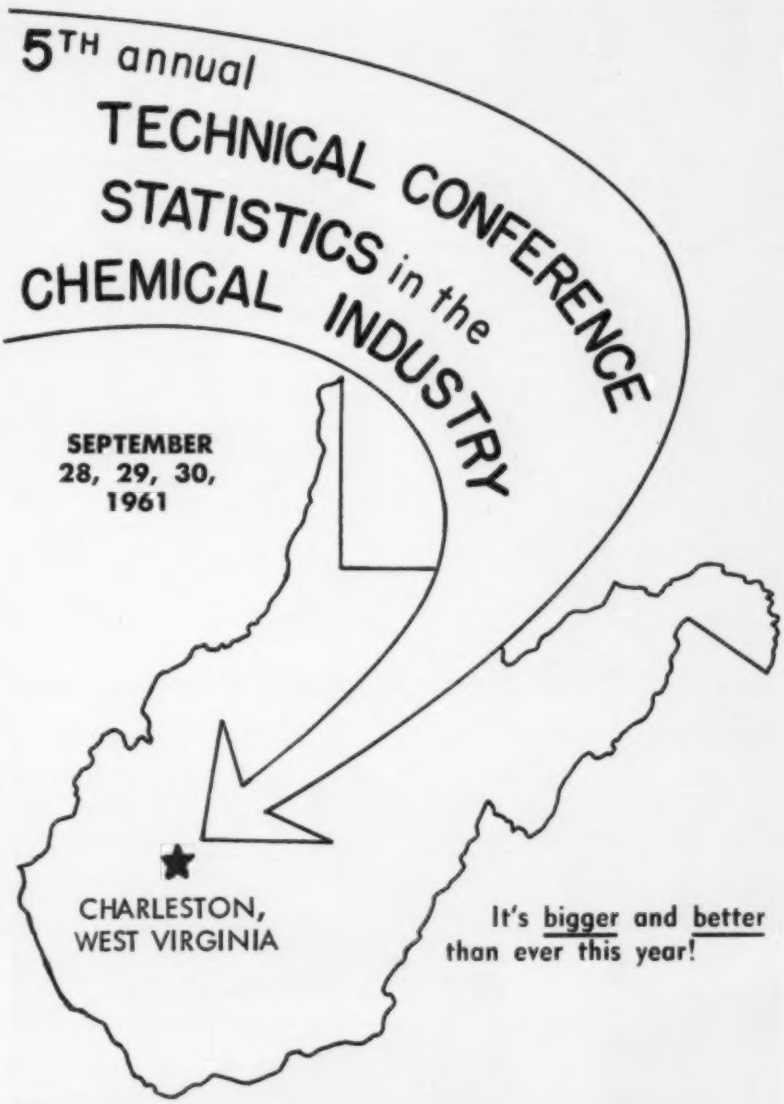

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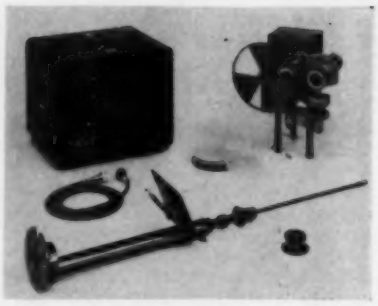
and theatre sound systems. It is useful in determining noise levels of appliances, office equipment and machinery. It will check conformity to specification in air conditioning, ventilation and flourescent lighting installation.

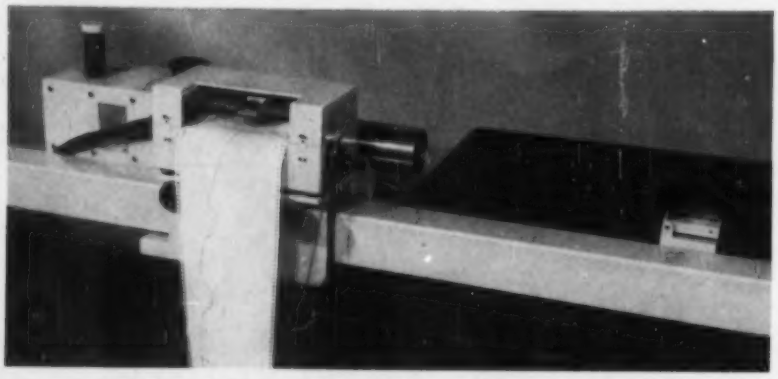
* * *

913—H. H. Scott, Inc., announces a new sound level meter (Model 412) designed to the new S1.4—1961 ASA standard. It operates over the exceptionally wide frequency range of five cps to 30 KC. A ceramic microphone allows the 412 to be used in temperatures ranging from zero degrees to 170 degrees. There is a built-in electro-acoustic calibrator to insure consistent accurate readings at all times. The new 412 operates on two batteries plus a single bias cell. Circuitry includes seven transistors. Batteries are replaced conveniently and cannot be inserted incorrectly. Unique design allows one-hand operation. There is a hinged, shock-mounted, printed circuit board making the 412 exceptionally easy to service. The meter will allow precise measurement of noise and sound in any location indoors and out. It will find extensive application in measurement of intensity of noise, and for determination of possible hearing damage. It will be useful in surveying the psychological and physiological effects of noise. Design engineers can use the Model 412 for measurement of noise produced by appliances, machines and automobiles. It will also help determine the acoustical properties of materials, enclosures and rooms. The 412 will find a place in the public address field for determination of appropriate sound levels in multi-channel systems. It can be used as a portable amplifier, voltmeter and attenuator in the audio frequency range. The sound level range is 24-150 db. It has the new ASA Standard A, B and C weightings. The amplifier section consists of four sub-miniature tubes, seven transistors, six diodes and one voltage regulating diode. The meter is quasi-RMS. Controls include main attenuator, meter-battery switch, weighting switch, calibration potentiometer and microphone equalizing switch. External connections include accessory microphone and vibration pickup input; output for earphone, analyzers, and recorders; meter circuit input for use with filter sets; two multi-purpose accessory power receptacles; internal power supply plug for interchangeable AC or rechargeable battery supply. This new meter measures 6¾ by 4⅛ by 11 inches, excluding microphone, and its weight is just over six pounds.



910—Evaporated thin film thicknesses and deposition rates now can be monitored and recorded for up to 20 successive coatings without breaking vacuum using a new control developed by Optics Technology, Inc. (formerly Spectracoat, Inc.). The new monitor system greatly simplifies control of both dielectric and metal film depositions in the production of optical and magnetic thin films and precision semiconductors. Elements of the system include a 90 cps chopped light source, a mirror system and glass blank monitor disk, a lead sulfide detector cell with objective lens and filter wheel, and a two-channel solid state amplifier-power supply designed to operate 10 mv recorders or meters. Operation of the new deposition monitoring system depends upon the measurement of the optical performance of the material being deposited. This is accomplished by projecting a chopped beam of white light and measuring the reflectance from the monitor disk in a vacuum chamber. Measurement is made at a specific wavelength, corresponding to any one of six interchangeable filters used ahead of the detector. When a non-absorbing dielectric film is deposited on the glass, the amount of light reflected at a given wavelength varies because of interference between the front and rear surfaces on the film, and is dependent on (1) the index of the material at that wavelength and (2) its thickness. In absorbing film such as a metal, the interference between front and rear surfaces is negligible. Transmittance and reflectance changes are therefore essentially monotonic and either may be used for measurement. The Optics Technology system normally provides for reflectance measurement, but it may be modified for transmittance measurement. Chopped light is used to make the instrument accurate despite changes in room light or the filament light inside the chamber. The monitoring disk component is installed through a half-inch hole in the base of the vacuum chamber. The light beam is transmitted through the side of glass vacuum chambers or through a port in metal chambers. The two-channel amplifier permits addition of a second optical monitor system without additional electronics. The system is sensitive throughout the infrared through the visible spectrum. Two

Another NEW Electro-Optical Development by Davidson—



The new Electro-Optical Recording System, D-716, graphically records either angle vs. time, or surface contour vs. distance along the surface by means of an automatic autocollimator and a recorder.

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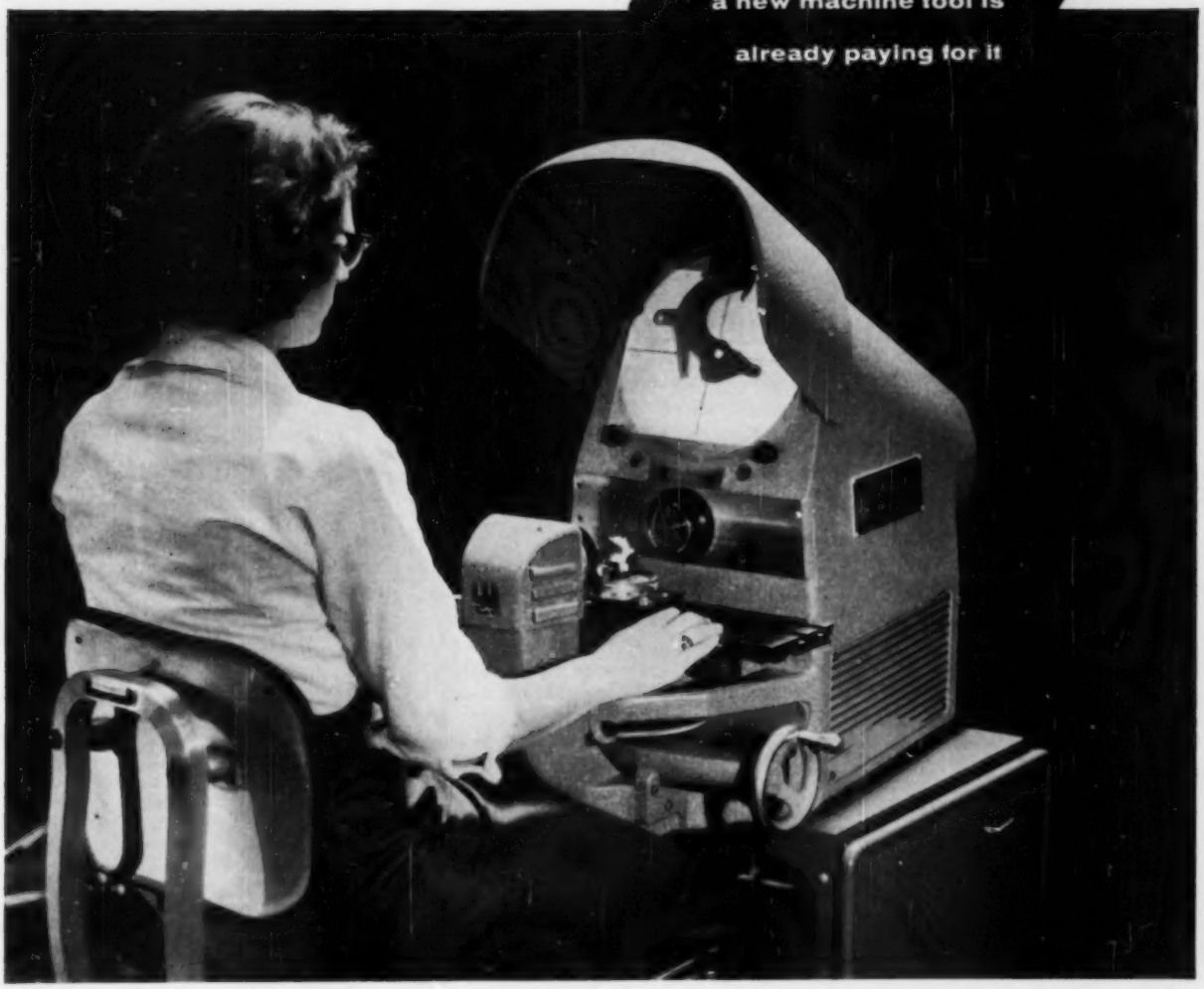

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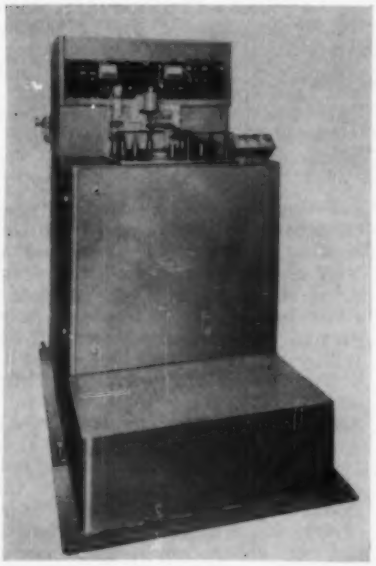
red filters normally are supplied between 1.5 and 2.5 microns. Accuracy of the system permits control of film thickness to plus-or-minus 0.25 percent.

907—The Industrial Electronics Division, Allen B. Du Mont Laboratories, Divisions of Fairchild Camera and Instrument Corp., announces Type 403-B, a new oscilloscope with a sensitivity of 50 microvolts per cm, with low noise level to permit resolution of signals as low as ten uv. Phenomena that are barely determinable within a dc to 1 mc frequency range are easily detected and displayed. The scope is useful beyond three mc and features high amplification with very low noise input. Sensitivity of the unit permits display of *non-amplified* outputs from most strain gages, pressure pick-ups, accelerometers, and other transducers. Its range of sweeps extends the instrument's usefulness to encompass almost any recurring phenomenon or transient. Its 21 calibrated sweeps extend from one usec/cm to five sec/cm with a vernier providing continuous adjustment between steps —and extends the five sec/cm range to slower than 25 sec/cm for a 250 second maximum sweep duration. A single sweep mode permits but one driven sweep of the time base to appear on the cathode-ray tube until the sweep is reset. An available accessory kit (Type 4001) allows the user to rearm the sweep from external switch closures such as those built into the synchro shutter of the Du Mont 450 oscilloscope record camera and found on cams and other rotating machinery. Other main features include a nominal drift of less than 500 uv/hour after warm-up, an AC stabilizing control that virtually eliminates DC drift, a sync ready indicator for indicating optimum trigger adjustments, no selected tubes or components, and a 5 KV CRT with a P31 phosphor normally supplied. P1, P2, P7, or P11 phosphors available, as well as metallized

screen for maximum light output. Primary fields of application are in transducer readout, vibration studies, electro-biological research, noise evaluation, standard laboratory scope use, electro cardioscope, electro encephalograph, transistor research, micro signal detection and study.

* * *

908—Electronic Applications Company has developed a transistorized portable AC Millivolt meter Model VT-3A with an accuracy of one percent that has a response of 20 cps to 600 kc and an entire response of ½ CPS to 5 mc. Meter scales are photographically calibrated to eliminate all non-linearity of the meter and amplifier. Another feature is the circuitry which gives a 22 megohm input impedance on all ranges 0.001 to 300 volts. The instrument is completely free from 117 vac line and small microvolt signals can be measured without the 60 cps beating problems found in similar equipment. The instrument's compact size, 6 by 9 by 5 inches, weighing 3½ lbs., permits a large 4½" meter and scale of excellent readability. Power consumption is 1/2000 that of conventional line operated instruments.



906—Typical of RCA's new equipment for automatic testing of valve springs is the unit designated Model 016. This machine checks the compressibility of automotive transmission regulator valve springs at speeds of up to 750 per hour, sorting the parts into "reject" and three acceptable categories within a tolerance of two pounds overall. "OK'd" parts are also automatically color coded according to the compressibility range in which they fall. Outstanding features are very high reliability, accuracy and 100 percent repeatability. Standard RCA gage heads and electronic modules are used throughout.

909—A new, modular, warp yarn inspector developed by the engineers of Fabrionics Corp. offers—in one, single instrument—complete protection against all objectionable defects of both length and diameter. Until Fabrionics introduced its new and completely redesigned Warp Yarn Monitor, Mark III, the yard producer was forced to use two separate instruments which were inconvenient, expensive, and required more operator attention. The new Warp Yarn Monitor with its unique, patented circuitry counts defects, stops the warper for their removal, detects end breaks, and detects length changes. The modular design of the new Warp Yarn Monitor is unusually versatile, flexible and compact while retaining the dependability and economy of earlier models. Like earlier models, the Mark III is a photoelectric defect detector that positively catches all defects—even those as small as a single broken filament. The distinctive, modular design of the new Warp Yarn Monitor permits two, three, or four electronic modules to be included in the compact monitor housing. Depending on the user's needs, the modules selected would include a power supply and any desired combination of amplifiers and the exclusive, Fabrionics Detect-All. The Detect-All, formerly packaged as a separate accessory for the Warp Yarn Monitor, is a sensitive detector that catches all linear defects above a predetermined size. Like the Monitor, it can either count defects or stop the warper, and its action is independent of that of the Monitor. The Detect-All has unusually high accuracy because a timing device cuts out extraneous yarn noises that interfere with the signal from the photoelectric detector.

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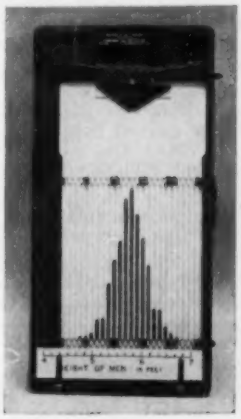

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New Literature

931—Consolidated Vacuum Corporation announces the availability of newly revised literature, Bulletin 4-70, 23 pages, on their complete line of HYGE Shock Testers. The HYGE Shock Tester develops its powerful repeatable thrust through differential gas pressures acting on the two faces of a thrust piston in a closed cylinder. Two types of testers are described in the bulletin. The three or six inch multi-waveform modular units are available in several different configurations, with metering pins to produce various shock waveforms. The second type, the dual—waveform package unit, is a complete, compact shock tester which will produce two different waveforms with external adjustments only.

* * *

932—Now available from Testing Machines Inc., a data sheet illustrating and describing the ply bond tester which was created to meet the need for additional physical testing of laminated products, gummed tape and other packaging materials requiring high strength. The plybond test is a quick and easy method for attaching a numerical value to the internal bonding strength of paper and paperboard.

933—A comprehensive manual of frequency and time standard systems is now available as Application Note No. 52 from Hewlett-Packard Co. The textual portion of this 56-page manual is divided into four main sections. The first section contains a general discussion of such problems as frequency and time control, radio propogation, time scales, etc. The second, third and fourth contain detailed consideration of system operation, frequency determination, and time determination, respectively. Several sample problems and solutions are included, and the text is supplemented with 16 illustrations and six tables. Hewlett-Packard instruments used as system components in the described applications include the Model 103AR and 104AR Quartz oscillators, 113AR/BR Frequency Divider and Clock, 114AR/BR Time Comparator, 120AR Oscilloscope, and 724AR/BR and 725 AR Standby Power Supplies. Data Sheets for these instruments are included as an appendix to the manual.

* * *

934—Speedmike—a new, improved, direct reading micrometer—is described in a colorfully illustrated folder offered by the manufacturer, J. T. Slocomb Company. The literature incorporates a large, clear, cutaway drawing depicting the design and construction features of the digitally read instrument. The various optional terminals and features available are also pictured.

* * *

935—Gerber Scientific Instrument Company announces publication of a technical bulletin describing the company's new 48 by 48 inch X-Y Plotter that is accurate to $\pm 0.001''$ over its entire working surface. The bulletin points out how the Plotter uses digital logic to eliminate drift and assure unprecedented precision in plotting and repeating. The choice of inputs and outputs is covered along with the various heads available for printing, scribing, inking, reading and exposing light-sensitive films.

* * *

936—CEC's Type 24-510 Radiflo Leak Detector is one of the most sensitive leak detection instruments ever built. Details on its efficient operation are now available in an eight-page bulletin from the Analytical Control Division of Consolidated Electrodynamics Corp., a subsidiary of Bell & Howell Co. The Radiflo is capable of testing hermetically sealed components for leaks in the 10^{-11} atm cc/sec range and is noted for efficient production-line testing capabilities. The 24-510's large capacity, short activation period, and automatic operation make it economically suitable for 100 per cent leak testing of electronic components such as transistors and relays.

* * *

937—An improved hydrostatic microhardness tester that permits direct, accurate readings, corresponding to Vickers, within 15 seconds by measuring resistance hydrostatically and which eliminates a microscope, conversion charts and complicated tables is illustrated and described in a new, two color bulletin recently issued by Newage Industries, Inc., 222 York Road, Jenkintown, Pa. An additional fluid control knob has been incorporated, allowing rapid zero adjustments. According to the manufacturer, many production and precision parts that could not be checked before can now be tested with accuracy, including small flat springs, small wire, tips of cutting tools, surgical needles, wire punches, surface layers, and thin sheet stock. The bulletin describes the fact that slight vibrations usually destructive to microscopic readings do not affect the Newage tester and it can be moved from department to department without fear of damage. The compact tester is illustrated with the large dial shown that is said to be easily read and easily adjusted to facilitate comparative readings which correspond to Vickers 100 to 1000 (equal to hardnesses ranging from Rockwell B64 to C70 or Knoop 500G, 117-94). The Newage microhardness tester has a one kg load

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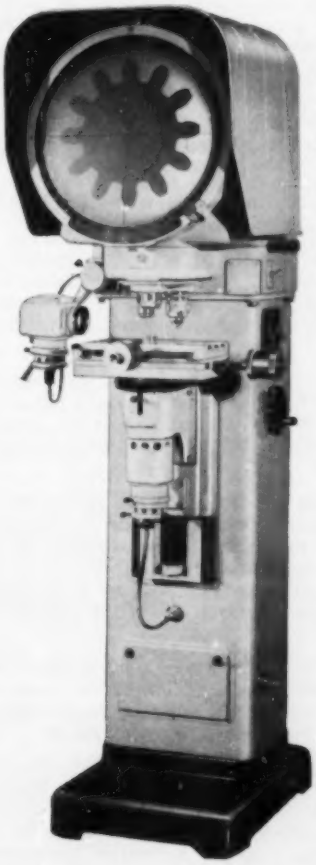

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Honorary Membership, ASTM Top Award to Simon Collier and Edward J. Albert

Two members of ASQC have been named to Honorary Membership in the American Society for Testing Materials—ASTM's top award to members.

Simon Collier, Fellow and past president, ASQC, and Edward J. Albert, a member ASQC, received certificates of election to Honorary Membership June 27. The presentation was made at the President's Luncheon, Chalfonte-Haddon Hall during the 64th Annual Meeting of the ASTM at Atlantic City, New Jersey.

Mr. Collier, formerly director of quality control, Johns-Manville Corp., New York, N.Y., is now a Quality Control Consultant on asbestos fibre and products.

A native of Salem, Mass., Mr. Collier was graduated from Worcester Polytechnic Institute in 1947 with a B.S. degree in chemistry. Upon graduation he became associated with Boston Belting Company for several years as a chemist, then was associated with the National Bureau of Standards as a chemist in charge of rubber work.

He joined Johns-Manville Corporation in 1923 as manager of Inspection and Control Department and became successively staff manager of that department then director of quality control, continuing in the latter position until his retirement in 1959. Since that time he has acted as Quality Control Consultant on asbestos fibre and products.

For years, Mr. Collier has been a foremost proponent of the statistical approach to Quality Control and has long recognized the need of quality conscientiousness both at the operating level and by top management. Because of this, he has felt that an educational approach is imperative and his activities and efforts among industries and engineering institutes have been directed along these lines.

Mr. Collier joined ASTM in 1926. He was a member of the Board of Directors of the Society from 1948 to 1951 and received the Society's Award of Merit in 1956.

Mr. Collier is a member of the Chemists' Club of New York City, the American Institute of Chemists, and the American Chemical Society.

Mr. Albert is chairman of the board, Thwing-Albert Instrument Co., Philadelphia, Pa. A native of Inghams Mill, N.Y., he began his career as a salesman for Ingersoll-Rand Company and then was associated with Canadian Allis-Chalmers Co., 1908-18, in the sales, engineering and design divisions. He studied mining at the University of Toronto.

In 1918 he joined Thwing Instrument Company and was successively secretary, general manager, and treasurer. The successor company, Thwing-Albert Instrument Co., was formed in 1935 with Mr. Albert as general manager. He was later appointed treasurer, and from 1946-57 was president. In 1957 he became chairman of the board.

Mr. Albert joined ASTM in 1930. He was a member of the ASTM Board of Directors from 1954 to 1957. He is an active member of the Philadelphia District Council, vice-chairman 1948-52, and was first chairman of the study committee which investigated and recommended the purchase of the present ASTM headquarters building 15 years ago. For the past three years, has been chairman of the Special Headquarters Building Expansion Committee.

Mr. Albert is a founder member of the Delaware Valley section, Technical Association of the Pulp and Paper Industry. In recognition of his work, the section instituted an Edward J. Albert Award, given annually to the author of the outstanding paper presented at the Society's May meeting.

He is past-president of the Scientific Apparatus Makers Association by which organization he was honored with the SAMA Award for a lifetime of accomplishments and service—service to the industry; service to science; service to the nation. This award has been made only ten times in the history of the association. He also is a fellow of the American Association for the Advancement of Science. Some other of his activities include membership in the Instrument Society of America, American Institute of Mining and Metallurgical Engineers, and American Petroleum Institute.

and penetrates as little as 0.000079 inch, and the patented loading mechanism is designed to eliminate friction and side thrust. The engineering concept behind the unit, its operation, warranty, price and specifications are also given in the bulletin.

* * *

938—New literature presents the Greibach concept of Selective Expansion for Electrical measurement, developed to meet the need for extremely accurate D.C. measurements over a wide range. The inherently high accuracy of a precision meter is limited by the inability of the observer to obtain objective readings as fine as 1/10 of the smallest division. The accuracy of reading is increased ten fold by expanding the usual six inch scale to 60 inches. After expansion the 1/10 division will become 0.01 per cent accurate. The manufacturer conservatively guarantees 0.25 per cent accuracy. Without use of external shunts or multipliers, up to five ranges are available, reading from as low as 100 microampres to one amp, or 100 millivolts to 100 volts with this single precision meter. Lightweight and compact, panel, mounted or portable Greibach Selective Expansion Meters are suggested for applications where extremely high accuracy with ruggedness and reliability are essential . . . such as standards laboratories, ground support for missiles, and critical measurements in the fields of solid state, electronic, atomic and nuclear research.

* * *

939—A new six-page bulletin has just been released by the Packard Instrument Co. describing its complete line of transistorized instruments for measurement of radioactivity and for chromatography. Included in this Bulletin AD-1000 are descriptions of the Tri-Carb Liquid Scintillation Spectrometer, the new Tri-Carb Flow Monitor and the new Auto-Gamma Spectrometer. With the exception of the Tri-Carb Flow Monitor, these instruments can be equipped for automatic or semi-automatic operation. Also described are Packard's new radiation counter for small animals and new instruments for paper, column and gas chromatography. Bulletin AD-1001, released at the same time, graphically illustrates the various models of the Packard Tri-Carb Scintillation Counter now available. Nine models are shown with automatic or semi-automatic operation, with options of refrigerated and non-refrigerated counting.

section briefs

AKRON-CANTON . . . June 15, the first meeting of the newly formed executive committee was held at Goodyear Hall . . . The coming year's activities should be off to a good start if the enthusiasm displayed is indicative of things to come . . .

Programming, membership, and publicity activities are well underway and should contribute significantly to bettering our Saddoris Award standing.

The Education Committee outlined their activities which will start in September with six different courses being offered at either Akron University, Orville, or North Canton.

Sept. 21, Dr. Lloyd S. Nelson, General Electric Co., Lamp Division, Cleveland, Ohio, the lead-off speaker for 1961-62 will present "Rapid Analysis of Engineering Data" . . . Dr. Nelson is presently the chairman of the Cleveland section as well as a National Director . . .

H. P. Pierce

ALLENTOWN-BETHLEHEM . . . June 21, annual Ladies' Night, Hotel Traylor . . . We started with a punchbowl at 6:30 p.m., with dinner at 7 p.m. . . . Corsages were presented to the ladies . . .

Bob Stanley, Western Electric Co., Allentown, Pa., showed some interesting pictures concerning the discovery of oil and talked on the "Statistical Aspects of the Discovery of Oil."

David F. Roberts

BATTLE CREEK-KALAMAZOO . . . June 13, the retiring officers and new officers for 1961-62 met at the home of newly elected chairman, Eugene E. Conolly, in Battle Creek to discuss plans for the coming season . . . There will be nine monthly meetings, with a possible tenth meeting as a plant tour . . .

A fall course in quality control is now in the planning stages.

Peter F. Koets

BIRMINGHAM . . . A meeting of the officers for 1961-62 was held at the Holiday Inn, Bessemer, Ala. A general outline of plans for the coming year was presented by the new chairman, Clyde Comer, B. F. Goodrich Co.

Preparations are almost complete for this year's meetings. Programs will be mailed in September.

A. D. Phillips

CHICAGO . . . I finally got on the ball—here are the section officers for the 1961-62 season: chairman—Frank Berman, Reynolds Metals Co.; vice chairman—section affairs—Lawrence R. Stickler, R. R. Donnelley & Sons Co.; vice chairman—program—Raymond Yetter, Teletype Corp.; vice chairman—membership—Mervin W. Fisher, Advance Transformer Co.; secretary—John Dittrich, Victor Adding Machine Co.; treasurer—John Louer, Artag Plastics; section directors—Mae Goodwin-Tarver, Continental Can Co., Robert W. Majeski, Victor Adding Machine Co., and Charles L. Matz, Quality Control Consultant; national director—Frederick Trowbridge, Hallicrafter Corp.; alternate national director—Robert W. Majeski, Victor Adding Machine Co.

The basic statistical quality control course will begin the latter part of September at the University of Illinois —Navy Pier Branch. For additional information, contact Robert J. Williams, Kellogg Switchboard, 6001 West 51st St., Chicago 38, Ill. Telephone KE 3-6700, Ext 500.

Sept. 13. first General Meeting of the season at the Teletype Corp., 5555 W. Touhy, Skokie Ill. . . . Luncheon will be followed by a "shop tour" . . .

An analysis of the tour will be presented by Pat Gerard, QC engineer at Teletype.

Warren Jones, Fellow, ASQC, and QC Consultant and Senior Partner of the firm, Management Control, will present "History of Quality Control."

For additional information, contact Reymond Yetter, Teletype Corp., 5555 W. Touhy Avenue, Skokie, Ill. Telephone CO 7-6700, Ext. 575.

Plan to attend one or more of the excellent educational courses offered by the section during the coming year. Also, our general meetings are always informative and interesting so circle a few of those dates on your calendar and plan to attend. Hope to see all of you soon and often!

John Dittrich

DAYTON . . . June 7, the final meeting of the 1960-61 season was an informal stag picnic at Delco Products Lodge, Kettering, Ohio . . . More than 30 members and guests enjoyed an evening complete with refreshments and entertainment . . . Chairman Bob Stockert officially turned the gavel over to the incoming chairman, John Condon . . .

Program chairman Ray Jackson is currently finalizing the program for the coming year. The first meeting of the 1961-62 season is set for Thursday evening, Sept. 14, 1961.

Ken Holliday

GEORGIA . . . Sept. 28, Georgia Tech, George Molzahn, QC manager, Lockheed Aircraft Corp., Marietta, Ga., will speak on "Manufacturing Reliability and Process Capability" . . .

New section officers are chairman—Dr. H.M. Wadsworth, Industrial Engineering Department, Georgia Institute of Technology; vice chairman—Dr. A. C. Cohen, Jr., director, Institute of Statistics, University of Georgia, Athens, Ga.; secretary—E. G. Field, E. G. Field and Associates, and treasurer—William W. Gay, staff statistician, Southern Bell Telephone and Telegraph Company.

The November meeting will be in Athens, Ga., at the Institute of Statistics.

E. G. Field

HAMILTON-MIDDLETOWN . . . June 3, annual Dinner Dance, LeSourdsville Amusement Park, Middletown,

Electronics Division News

The annual dinner and meeting of the Electronics Division, ASQC, was held June 5 at Stouffer's Restaurant following the opening day activities of the 15th ASQC Convention and Exhibit, Philadelphia, Pa.

Seventy persons in attendance included past officers and a number of Society officers. Gordon Beckhart, chairman, Electronics Division, reviewed the past and future programs of the Division. He called upon many of the active workers for brief statements.

Officers and Councillors for 1961-62

Officers are H. Dean Voegtlen, chairman; Harry W. Shifflett, chairman elect; John F. Teunisson, secretary, and Alexander Sternberg, treasurer.

Councillors and Districts are Robert G. Fitzgibbons, 1; Frank Gall, 2; George Scheel, 3; John Pringle, 4; William Rombach, 5; Bob Williams, 6; John Webb, 8; John Euler, 9; Herbert Estes, 10; Martin Joseph, 11; Vida G. Hildyard, 12; John A. Duggan, 13; Herbert B. Epstein, 14; Harold Z. Snyder, 15; E. V. Bersinger, 16, and John Ogden, 17.

Ohio . . . 33 members and guests turned up to enjoy family style chicken and dancing under the stars . . .

At the short business meeting, new officers were introduced. The new chairman, Joe Mead, outlined plans for the coming season, and the outgoing chairman, DuWayne Carlson, was presented with an attache case.

Plans have nearly jelled for all of next season's program nights. The final rearrangement of specific dates for speakers and plant tours is all that remains to be firmed.

Sept. 13, dinner meeting with a speaker in Hamilton, Ohio . . .

Oct. 4, plant tour, Middletown, Ohio . . .

D. R. Carlson

HARRISBURG . . . June 8, Mt. Joy American Legion Home . . . A buffet dinner was served . . . Games and cards were enjoyed by members and guests . . .

The following officers were installed for the 1961-62 season: chairman — H. Gross, RCA, Lancaster; vice chairman—O. Fox, Borg-Warner, York; secretary—J. T. Fasnacht, Hamilton Watch Co., Lancaster, and treasurer —R. E. Lehman, Carlisle Tire and Rubber Co., Carlisle.

Attractive prizes given as door prizes by the various local industries included ballpoint pens, lighters, flashlights, a throw rug, silver candle sticks, tie clasps, cuff links and a badminton set.

Ann Englehart

HARTFORD . . . During the summer months your new executive committee was working to make the 1961-62 season the best in the history of Hartford. Seven monthly meetings will be scheduled. For the third consecutive year, a Ladies' Night is scheduled for the first meeting. This night will also be Management Award Night.

Another area of intense concentration by your executive committee was the development of the education program sponsored by the Hartford section. Also, the Hartford section would be interested in hearing from anyone interested in a master's level program in Industrial Statistics at a local college.

In addition to a Third Annual One Day Seminar, the section will also sponsor the New England Quality Control Conference in October.

L. Sespaniak

UNIVERSITY OF IOWA . . . Sept. 22, 8 p.m., Moline, Ill., International Harvester Night, topic—"Process Control" . . . .

E. B. Godsey

KANSAS CITY . . . June 15, the presence of a large number of ladies brightened this meeting of the Kansas City section . . . Highlights of the ASQC Convention were presented by George Cohan . . .

Mr. Cohan also spent some time in program planning, indicating that several prospective speakers for the coming year had been contacted.

Dave Stevenson brought us a special report on the Inspectioneering Workshop, which was held at the Convention.

H. Afton Taylor

LEXINGTON . . . June 17, the annual Dinner Dance closed this year's activities . . .

The 1961-62 program theme will be "Quality Control in the Space Age." The opening program, Sept. 21, will have Joseph L. Bernick, quality manager, Nuclear Division, Martin Co., Baltimore, Md., speaking on "Nuclear Energy Goes to Work."

James C. Graff

LIMA . . . Oct. 6-7, intensive course in reliability will be sponsored by the Lima section . . . Harmon S. Bayer, Quality Control Consultant, Detroit, Mich., will be the instructor . . . For information, contact D. C. Fultz, Lima Engine Plant, Ford Motor Co., Lima, Ohio . . .

C. J. Dukro

LOS ANGELES . . . The section recently heard Air Force, Army, and Navy representatives present future requirements for the quality of products intended for military use.

The panel included Col. C. Peterson, Air Force plant representative, Douglas Aircraft; Maj. F. Gibson, Inspection Division, Los Angeles Ordnance District, and Cmdr. R. W. Smiley, USN, Engineering and Inspection, Special Products Office (Polaris) Sunnyvale.

The panel members forecast that products produced for military use will receive more thorough quality investigations in the future.

Air Force—Colonel Peterson gave a brief review of how quality control originated during World War II with some 14,000 Air Force Inspectors checking suppliers' quality or duplicating the contractors' efforts, making a second check. The Air Force along with major contractors agreed to a common system. This agreement was outlined as a general military specification MIL-Q-5923, with the specification—Quality Control—becoming a management function on a par with Engineering and Manufacturing.

With improvements and changes in the general quality specification, the present Quality Control requirements as outlined in MIL-Q-9858 has become a general agreement among all contractors and branches of the service.

Colonel Peterson pointed out that the present number of 3,400 USAF inspectors compared with 14,000 during World War II is due to the contractors establishing firm quality control departments reporting to top management.

Army—Major Gibson, speaking for the Army Ordnance and Signal Corps, pointed out that the Los Angeles Ordnance District is one of eleven districts which covers the lower half of California, all of Arizona, New Mexico, Utah, and certain sections of Nevada and Texas.

The Los Angeles District currently is administering approximately 1200 contracts with a face value of 1.8 billion dollars, and an undelivered value of 450 million dollars. During the past fiscal year, the district negotiated contracts for approximately 300 million dollars

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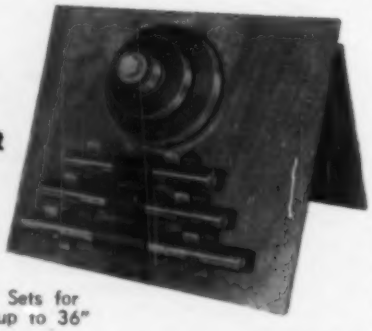

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in new ordnance business in its procurement area. During the same period about 300 million dollars in defense material was shipped to our Armed Forces in this country and overseas.

The district is staffed by 19 Army officers and 740 civilians, providing an annual payroll in the Los Angeles area of about five million dollars.

As a reminder, Major Gibson told some 225 QC heads representing major contractors in the Los Angeles area to look for future requirements to establish calibration laboratories and to keep a close watch on blueprint and drawing controls.

Navy—Commander Smiley, USN, firmly stated that he, as special project officer for Engineering and Inspection, is not at all happy with the quality that the Navy has received in the past. The major area for improvement lies in better design control by the second and third level supplier. He said that QC and reliability will evolve into a common system and that future contracts will require suppliers to meet specific requirements for quality and reliability on the Polaris program.

Commander Smiley stated, "Quality is a requirement of manufacturing and reliability is a requirement of engineering. The system for controlling these requirements will rest in a common system reporting to management, known always as Quality Control."

The quality control and reliability dollar has exceeded the direct cost of engineering and manufacturing; therefore, some type of quality control incentive program, now under study, will be written into the contracts of the future, concluded Commander Smiley.

Steve S. Kozich

LOS ANGELES—VALLEY SUBSECTION . . . June 22, dinner meeting, Hody's Restaurant, North Hollywood, Calif. . . . William X. Lamb, Division of Reliability, Bendix Pacific, presented "Reliability Growth" . . .

Nick Chilikos

LOUISVILLE . . . June 13, the newly elected section chairman, Ray Evans, got affairs well underway by holding the first executive committee meeting at Lynn's Restaurant . . .

The purpose of the meeting was not only to enjoy a steak dinner, but to plan an attack on the coming season with the aid of officers and committee chairmen. Quite a bit of time and effort is being put on methods to increase the membership of the section.

The program for 1961-62 will be well diversified, with speakers and attractive events for each meeting. The new chairmen revealed enthusiastic plans to utilize a "point system" to encourage each member to take an active part in the work of the section. He also has plans and hopes to establish a section newsletter early in 1962.

Monroe J. Oates

MEMPHIS . . . June 20, Annual Meeting was held at Plough, Inc. . . . A film, "Operations Research, What It Is, How It Works, Scope and Limitations," was presented by Glenn Olree, Buckeye Cellulose Corp. . . . Delicious refreshments were served at the conclusion—compliments of Plough, Inc. . . .

W. L. Dickerson

MERRIMACK VALLEY . . . Sept. 7, first regular meeting of the 1961-62 season at the Yankee Doodle Restaurant, Lawrence, Mass. . . .

Sept. 22, fall symposium on "Packaging and Packing Materials" at the Lowell Technological Institute, Lowell, Mass. . . .

The format will be as in past events, with double sessions in the morning and afternoon.

This will be the third in a series of symposia at Lowell Tech. After last year's topics of "Quality Control in Small Industry" and "Control of Special Processes" we will continue our coverage of specialized areas with this all day meeting on a topic of considerable interest to both the extensive electro-mechanical and paper industries in the Merrimack Valley area.

Fred E. Ryan

METROPOLITAN . . . Sept. 9, Thirteenth Annual All Day Conference sponsored by Rutgers • The State University and the Metropolitan section, ASQC . . .

The program will have items of interest for all members of the quality control team and will include six concurrent panels on applications of statistics in the ceramic, mechanical, chemical, and electronic industries plus two panels on administrative applications of statistics in auditing and accounting.

The Rutgers Conference annually attracts some 600 men and women from a wide segment of industry to the campus at New Brunswick. "Quality Control and Statistics in Industry" includes basic and advanced topics of wide interest to members of the industrial, governmental, and business communities.

Section officers for the current season are chairman—J. O. Cully, Ward Leonard Electric Co.; vice chairmen—F. C. McLaughlin, General Electric Co., New York City, and L. R. Dorsky, Remington Rand Systems; secretary—E. E. Allen, American Can Co., and treasurer—E. C. Torkelson, Bell Telephone Laboratories.

In order to increase interest, and in effect increase the number of meetings during the coming year, the new officers are planning at least two monthly meetings that will have three concurrent sessions on the same evening. These sessions will be on widely separated topics of interest to the greatest proportion of the membership.

Past chairman Bill Frey expressed his appreciation to all who participated and helped during the 1960-61 season.

Stephen G. Orban

MEXICO CITY . . . The section *Ciudad de Mexico* has just completed the second annual course in basic quality control. The course was held at the *"Camara Nal. de la Industria de Transformacion* of the City of Mexico

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THE ELLIOTT HI-VISION PROGRAM

(See page 45)

during the second and third week of the month of June.

Sept. 9, the section will celebrate the tenth year of incorporation to the American Society for Quality Control . . . We are organizing a special meeting with the attendance of several outstanding personalities of the industry and scientific circles . . .

Domingo M. López

MID-HUDSON . . . The section held its last meeting of the season at the Di Prima Hotel in Highland, N.Y.

As this was the last meeting of the season, a change was made in the usual format. The arrangement committee secured the services of Edward Fitchett, the Man of Magic, and Claude A. O'Callaghan, the original Irishman of entertainment.

G. Overbach, chairman for the past season, and Walter W. Wagner, incoming chairman, reported on the seasons activities and the programs planned for the future. Mr. Wagner also announced his appointments to aid him in conducting the section program for the coming season.

William Tuceling, chairman of the section's One Day Seminar to be held at Vassar College Sept. 16, reports that plans are going according to schedule. Several of the speakers have been engaged and brochures are being distributed to area industries. Additional information on the seminar may be obtained from E. L. Leadbitter, Dept. 301, Bldg. 002-3, International Business Machines, Poughkeepsie, N.Y.

E. L. Leadbitter

MONTREAL . . . June 14, the annual Dinner Meeting was held in Salon A of the Queens Hotel . . . 30 members and 38 guests were present when certificates for proficiency were awarded to 31 persons who attended the elementary and advanced QC courses sponsored by the Montreal section . . .

Morris Kaplan, technical director, Consumers Union, U. S. Inc., Mount Vernon, N. Y., presented "The Consumers Union and How It Operates." His introductory remarks covered the aims and objectives of the Consumers Union. He explained that the sole purpose of this nonprofit organization is the protection of the consumer.

A film entitled "Consumers Want to Know" showed how actual tests are conducted; how conclusions are reached regarding the quality of the product, and how the reports are analyzed before they are published in *"Consumer Reports,"* the official magazine of the Consumers Union.

Upon completion of the film there was a question period, which turned out to be the most interesting part of what had been, up to that point, a most entertaining evening.

J. J. Fitzsimons

GREATER MUSKEGON . . . June 28, annual board meeting, Bill Stern's Steak House . . . New and retiring board members were present to transfer all necessary books and documents and to formulate plans for 1961-62 . . .

Sept. 30, QC Seminar, Occidental Hotel . . . Henry Elliot, Sealed Power Corp., a charter member of our section, has consented to be a vice chairman and will assist chairman Merrill Bailey and vice chairmen Bill Poe, Elwood Presley, Mike Pascavis and Jack Fortenbacher . . .

William A. Hume

NORTHEAST TENNESSEE . . . June 15, the first presentation of a four-part pre-session clinic was given by Carl Wilson, Tennessee Eastman, at the Eastman Auditorium . . . The topic—"Meaning of Precision and Accuracy" . . .

A meeting of all old and new officers and chairmen was held prior to the meeting. Plans were laid for the coming year's activities.

After the clinic, dinner was served at Skobie's Restaurant. The meeting resumed after dinner in the auditorium and Tom R. Bainbridge, assistant superintendent of quality and standards, Tennessee Eastman, was guest speaker. Mr. Bainbridge spoke on "Estimating Sampling and Test Errors." The talk centered around the calculation of errors generated by testers, test equipment, and sampling methods. Mr. Bainbridge also explained how accurate measurements could be made with reduced testing.

Meeting attendance—23 members and nine guests.

Mike Gomez

OMAHA-LINCOLN . . . June 9, Ladies' Night, Marchio's Steak House, Omaha, Nebr., M. B. Crabill, director of the Division of Sanitation, Omaha-Douglas County and a member of the Omaha-Lincoln section, ASQC, spoke on "Garbage, Rats, and Politics" . . .

T. C. Anker

ORANGE EMPIRE . . . June 20, Ladies' Night Dinner Meeting at the Waterwheel Restaurant . . . J. Y. McClure, president, ASQC, installed the following new officers: chairman—Edgar A. Steinmeyer, Kwikset Locks; vice chairman—Charles L. Kleppsattel, Hughes Semi-Conductor; secretary—William B. Nelson, Nortronics; treasurer—Alfred E. Candelaria, Norden Co. . . .

Mr. McClure presented slides showing the National Headquarters and various key personnel. The topic of Mr. McClure's address—"Philosophy, Policy, and Goals of the ASQC"—was very informative and interesting to all members and ladies.

All ladies received a corsage. Mr. Steinmeyer was presented with an engraved gavel by Mr. McClure, who was in turn presented with a Quik Set Lock—desk type ash tray by Mr. Steinmeyer.

The members were very happy to welcome Mr. McClure and wish to express their appreciation to him for taking time from his busy schedule to attend and address the section.

Henry W. McKee

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Officers installed at the June 20 meeting of the Orange Empire section, ASQC, are Charles L. Kleppsattel, vice chairman; Edgar A. Steinmeyer, chairman; William B. Nelson, secretary, and Alfred E. Candelaria, treas.

PHILADELPHIA . . . June 28, a meeting of the executive committee and chairmen was held to discuss plans for the coming year . . .

Outgoing chairman Stan Hart gave a brief resume of past events and activities of the operating committees before turning over the reins to incoming chairman Tom Moran.

Mr. Moran announced the following committee chairmen: Thaddeus Bochey, placement service; Harry Griener, membership; Mary Wolcott, reservations; James Miller, office operation; Arnold Dodds, conference; William Hepburn, publications; Alexander Sternberg, Saddoris Award; George Branin, auditor, and Stanley Hart, advisor.

Symposium chairman Arnold Dodds presented his plans for the Sixth Annual Symposium to be held in September at Pennsylvania State University, Ogontz campus, and also appointed Bernard Rosenberg as secretary for the Symposium.

June 3, the section presented the first annual Irwin S. Hoffer award to Maj. Gen. Webster Anderson, executive director, Military Clothing and Textile Supply Agency, Philadelphia, Pa. . . .

The award, named for one of the founding members of the Philadelphia section, was presented by the founder, Dr. Irwin S. Hoffer, to General Anderson for outstanding service in stimulating application of statistical quality control principles by industries in the Delaware Valley.

The citation read "Your wholehearted indorsement of these principles has contributed greatly to more efficient and systematic management in this area and throughout the nation."

The award was presented to General Anderson prior to his departure to accept an appointment as Quartermaster General of the U.S. Army in Washington, D.C.

The award will be presented annually to the individual in the Delaware Valley, not a member of ASQC, who has done the most during the preceding year to further quality control in the Delaware Valley.

Representatives of the clothing and textile industry recently completed a course in quality control practices and principles. The course was jointly sponsored by the section and by the Military Clothing and Textile Supply Agency (MC&TSA).

Certificates were presented during the May 11 meeting at the Germantown Cricket Club. Major Harlan W. Tucker, MC&TSA, presented "Quality Control in the Clothing and Textile Industries from the Standpoint of a Military Buyer."

Instructors were invited from the Kurt Salmon Assoc.

Albert G. Dettore

PIEDMONT . . . The section has installed the following officers for the coming year: chairman—A. A. Wolf, Kearfott Co., Black Mountain, N.C.; secretary—W. D. Lineback, C. P. Claire, Asheville, N.C.; and treasurer—G. J. Trump, Amcel Corp., Ashville, N.C.

Section meetings will be held in Asheville, N.C., at the Battery Park Hotel each second Tuesday night.

Programs for the coming year will be formulated and announced by section mail. Our meetings in the past have been attended by more than 30 persons. We wish to express appreciation to members who travel great distances. We invite you to write to our secretary to express your suggestions. We want your company to be represented in this section.

Clifton Smith

PITTSFIELD . . . June 17, the section held its annual outing and picnic at "The Oak and Spruce" in Lee, Mass. . . . Attendance was very good and so was the weatherman . . .

Prizes were given for such things as golf, horseshoes, swimming, archery and kite flying.

We were served a buffet style supper of charcoal broiled chicken, baked beans, salad, cake and coffee. After dinner there was dancing. All in all it was a well planned day.

Howard J. Greenslet

RHODE ISLAND . . . June 1, executive committee meeting . . . Assignments of the various committee chairmen were reviewed and plans for the coming year were discussed . . .

The continuing pressure for improved quality and reliability by the biggest customer on this continent, the U.S. Government, have required many contractors to build quality assurance organizations rapidly without

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detailed knowledge of what these functions should do. The section is fortunate this year to have George Sakalaris, supervisor, INSMAT, as our "kick-off" speaker Sept. 21. He will tell us about the Navy Quality Assurance requirements for government contractors. A lively discussion on "What Is Quality Assurance" is anticipated.

Paul K. Moffat

SACRAMENTO . . . R. D. Geckler, vice president and manager of the Solid Rocket Plant, Aerojet-General Corp., Sacramento, Calif., will be the guest speaker at the section's September meeting. His topic—"The Role of Management in Reliability."

M. K. Walker

ST. LOUIS . . . May 19, C. D. Jeffcoat, manager of reliability engineering, Westinghouse Air Arm Division, very ably presented "Reliability" . . . It was an excellent follow-up to the material presented at our Spring Conference Apr. 22, the theme for which was "Anatomy of Reliability" . . . The Conference was attended by 130 members and friends with 19 companies represented . . .

Two scholarship awards were presented at the May 19 meeting. First place went to David Heiman of Washington University and second place to Richard A. Bauer, St. Louis University.

Harry O. Hehner recently presented "Probability and Statistics" to eighth grade and high school classes in the area. John Randall and others report excellent reception of the presentation.

Our theme for the coming year is "Action." Attend the meetings and workshops and you will not miss loads of new ideas and applications that will not be found at book level for several years. Our active members are "years ahead" of the casual "readers."

John W. Bredfeldt

SOUTH TEXAS . . . Plans are being made for this year's program which will follow a different format than in the past. We urge all members to come and evaluate the new deal.

Ed Franklin

Second Annual Industrial Seminar

The Mid-Hudson section, ASQC, will sponsor its Second Annual Industrial Seminar Sept. 16 at Vassar College, Poughkeepsie, N.Y.

Central theme for this year's presentation will be "Assured Customer Acceptance Through Advanced Techniques."

William Tuceling, general chairman, advises that the program has been designed for management and technical people interested in the problems of maintaining customer satisfaction through a program of testing by utilizing advanced techniques and test equipment.

R. H. Gerty, R. E. Warr, J. T. Rowinski, and C. R. Lemley will discuss techniques of product assurance through field feedback reporting and analysis. K. W. Davidson, T. A. Budne, and P. C. Clifford, along with others, will discuss manufacturing control techniques related to customer assurance.

Topics to be covered during the four sessions are: reliability in production; product performance reporting; design techniques, evaluation of reliability, and other topics related to the theme of the program.

A fee of ten dollars covers dinner, transactions, and the seminar. Registration starts at 9 a.m.

For additional information, contact Casper J. Rose, registration chairman, West Road, Poughkeepsie, N.Y.

Major Harlan W. Tucker, technical policy office chief of the Military Clothing and Textile Supply Agency, is welcomed to a dinner-meeting of the Philadelphia section, ASQC, by Stanley S. Hart, section chairman. Major Tucker served as coordinator for a special Quality Control course conducted jointly by the Society and the Agency.

TOLEDO . . . The program committee, under the chairmanship of Roy C. Settengren, General Mills, Inc., and James C. Clark, Permaglass, Inc., had the 1961-62 program finalized by July 1. Members of the committee are Donald W. Anthony, Owens-Corning Fiberglass; Hilton C. Fetting, Libbey-Owens-Ford Glass Co.; George H. Barrows, M & S Morenci Corp.; Gerald K. Vieson, Continental Aviation and Engineering Corp.; James E. Davis, Johns-Manville Fiberglass, Inc.; E. Stanley Melick, Brush Beryllium Co.; Theodore R. Meyer, Kimble Glass Co.; Fred D. Reardon, Ford Motor Co., and Keith L. Lewis, M & S Manufacturing Co.

Mr. Lewis, Margaret A. Tobin, and Roland E. Rockwell attended a District 8 meeting in Cincinnati, Ohio, on June 17. Mr. Lewis, District 8 representative, was the moderator for this event. The attendees went on record in favor of an active district representative in light of the excellent results this has produced during the past year in District 8.

Paul E. Smith, membership chairman, is busy interesting potential members in ASQC and reminding the few old members who have not renewed to do so.

R. E. Rockwell

YOUNGSTOWN . . . New section officers are Charles E. Weitz, chairman; Charles R. Branfield, vice chairman; Donald C. Burkle, secretary, and Arthur J. Grady Jr., treasurer.

C. T. Wirebaugh

WASHINGTON, D.C. . . . The section in cooperation with the Department of Statistics, George Washington University, and the Office of Naval Research, will sponsor a colloquium in probability and statistics during the academic year 1961-62.

The program for the coming year is now being planned to include such topics as engineering and mathematical aspects of reliability, data processing, the training program, vendor-vendee relations and related subjects.

The speaker for the September meeting has not as yet been selected.

M. Alethia Mayes

WESTERN MASSACHUSETTS . . . Sept. 26, One Day Quality Assurance educational program at the Sheraton Motor Inn, Springfield, Mass. . . .

The program is designed as a service to companies involved in government contract work who either need orientation in quality assurance requirements or who have had persistent problems in fulfilling these requirements to government satisfaction.

Though main emphasis will be put on the Army's quality assurance program, it is expected that Mr. Ramsey will be conversant with similar programs of the

Navy and Air Force. This program should be of interest not only to people concerned with government contracts, but also to those interested in introducing quality assurance into their own companies. The program will consist of five one-hour sessions beginning at 2 p.m. Dinner will be served at 5:30 p.m., sessions will be resumed at 7 p.m. and will be concluded at 9 p.m.

June 15, annual outing and steak roast at Strathmore Park, Woronoco, Mass. . . . Activities included softball, golf and horseshoes . . . A good time was had by all . . .

Alan J. Donnelly

Significant Differences

. . . AKRON-CANTON—**Vince Gatto,** General Tire and Rubber Co., will be arrangements chairman for the 1961-62 season.

. . . ALLENTOWN-BETHLEHEM — Western Electric, Allentown, Pa., welcomed into their organization two new QC engineers—**Charles T. Tarr,** a metalurgical engineering graduate of Purdue University, and **Charles A. Smith,** an industrial engineering graduate of West Virginia University.

Vince Lukach, also a QC engineer at Western Electric, Allentown, Pa., will participate in the Thirteenth Annual All Day Conference Sept. 9 at Rutgers • The State University, New Brunswick, N.J. He will present "Statistical Methods Help Solve a Glass Problem."

. . . BIRMINGHAM—**Wyllys G. Stanton,** professor at the University of Alabama, who recently recovered from an operation involving major surgery, is now in a hospital in Montgomery, Ala., following an automobile accident.

. . . HARRISBURG—There are 16 persons who have had 100 percent attendance at 1960-61 season meetings.

. . . INDIANAPOLIS — July 1, **Dr. Irving W. Burr,** Purdue University, became editorial chairman of *Industrial Quality Control.* **Dr. Charles R. Hicks** will become Book Reviews editor.

Dr. H. Latham Breunig, Eli Lilly & Co., celebrated his 25th year with the company on Aug. 10, 1961.

. . . LOUISVILLE—Officers for 1961-62 are chairman—**Ray Evans,** Philip Morris, Inc.; vice chairman—**Miss Flora Juergens,** Colgate-Palmolive Co.; secretary — **Robert Gilliland,** the Klarer Co., and treasurer—**Charles Davis,** Philip Morris, Inc.

. . . MILWAUKEE — **J. Stuart Hunter,** editor of *Technometrics,* is leaving the Army's Mathematics Research Center at Madison, Wis., in September to become associate professor of chemical engineering at Princeton University.

. . . NORTHEAST TENNESSEE—**J. T. Johnston,** past section chairman, spoke to the Anderson Street Methodist Church Mens' Club on June 22. His topic was "Challenge of Space Exploration."

The officers and members of the Northeast Tennessee section are proud of the section's selection as the only master section in ASQC.

Section members in attendance at the National Convention included **Bill Morgan,** section chairman, and **Hubert Hill, Ralph DeBusk, Stan Murray, Tom Odom** and **Bob Beard.**

. . . ORANGE EMPIRE—**Fred A. Peck** has been appointed QC director for the Data Recorders Division, Consolidated Electrodynamics Corp. Mr. Peck had spent the past 11 years with Hughes Aircraft Co., where he became chief of quality control engineering, El Segundo Division; director of quality control and reliability, Semiconductor Division, and administrator, corporate staff. He is past chairman of the executive board of the Orange Empire section, ASQC, and a member of the American Management Association. He was co-chairman of a recent AMA seminar on quality control organization.

. . . ORLANDO-CAPE CANAVERAL — **Mel Snow,** a graduate industrial management engineer, has been named QC manager for the Guided Missiles Range Division, Pan American Airways. He will direct the company's overall quality control program, concentrating in six areas—marine, test equipment and physical standards laboratory, electronic equipment, photography, supply and facilities. Mr. Snow is currently working on his PhD in Industrial Administration from the University of Pittsburgh.

. . . PHILADELPHIA—**Charles R. Wiegand** has been appointed head of the quality control group, Navigation Computer Corp., Valley Forge Industrial Park, Norristown, Pa. Mr. Wiegand was formerly QC manager, Burroughs Research Center, Paoli.

. . . PITTSFIELD—**Joseph A. Trowbridge,** our newly elected chairman, has been transferred from General Electric, Pittsfield, to General Electric, Everett, Mass. Since Mr. Trowbridge joined GE in 1947, he has held such jobs as electrical designer, engineering department; test engineer, Power Transformer; test engineer, Jet Engine; specification engineer for Underwater Equipment; design engineer, Underwater Equipment; QC engineer for Fire Control Equipment; method and time standards engineer; quality control engineer, Ordnance Department, and many others.

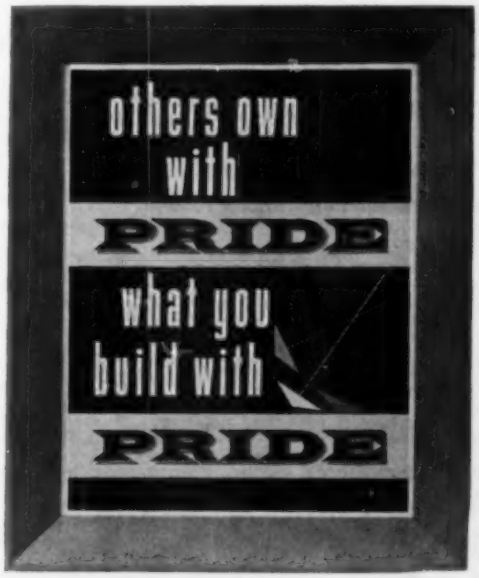
Mr. Trowbridge has taken many training courses at GE. He is a graduate of Harvard with a BS in Electrical Engineering.

His new position will be that of supervisor of process control engineering, quality control.

The section wishes Mr. Trowbridge the best of luck in his new position.

. . . SACRAMENTO—With an 11 percent increase in membership between May and July, planning for hosting the 1963 Western Regional Conference, and a series of educational conferences, our new officers and chairmen have enough momentum to carry them over the next two years. Subjects such as nondestructive testing, purchase order and supplier control, and metrology are common topics of the executive committee meetings as planning gets under full steam.

. . . SOUTH TEXAS—**Jerry Moyer** was on the teaching staff for the joint TAPPI-CPPA (Technical Association



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(See page 53)

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General Publication No. 5

This ASQC report provides the necessary theory for one particular use of the control chart for number of defects. Edwin G. Olds and Edmund B. McCue investigate **The Power to Detect a Single Slippage and the Probability of a Type I Error for the Upper Three-Sigma Limit Control Chart for Number of Defects, No Standard Given.**

A previous technical report by Mr. Olds, GP No. 4, discussed an alternate procedure which used only an upper control limit for the control chart for fraction defective. In GP No. 4 it was assumed that the numbers of defective units per sample had binomial distributions.

Methods were developed for obtaining the power of the chart to detect a single slippage and for obtaining the probability of a Type I error.

GP No. 5 assumes that the defects per sample have Poisson distributions. The methods of the previous report are used to solve parallel problems. It is proven that the power characteristics of the defects-per-unit chart are limiting cases for the corresponding characteristics of the fraction defective chart.

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Fourth Annual RIT-SQC Award Presented to Warren L. Rhodes

The Fourth Annual RIT-SQC Award was presented June 30 to Warren L. Rhodes at the conclusion of the 11th annual Quality Control for the Graphic Industries program which attracted 30 top management people from all over the United States.

Mr. Rhodes is director of the Graphic Arts Research Department, Rochester Institute of Technology. The department is the largest of its kind on any campus in the United States.

The Award was presented by Alfred L. Davis, RIT's vice-president for Development and Public Relations and a past president, ASQC. The award is made annually to the individual in the graphic arts field who is felt to have made an outstanding contribution to the advancement of statistical quality control in the graphic arts.

Mr. Rhodes is assistant director of the seminar on statistical quality control and of the seminar on color control conducted annually by RIT. He is the author of numerous papers and articles which have been published here and abroad.

He is president of the Technical Association of the Graphic Arts, and a member of the Technical Association of the Pulp and Paper Industry, and a member of the Research and Engineering Council of the Graphic Arts Industry. He is editor of the Inter-Society Color Council Newsletter and has represented RIT at four meetings of the International Conference of Printing Research Institute.

A native of Colorado, Mr. Rhodes attended the University of Colorado and RIT. He was appointed to his present post in 1955.

Previous winners of the award have been B. S. Sooy, S. Curtis and Son; Donald Macaulay, president, Paper and Printing Quality Control, Inc., and Dr. Carl Noble, director, Consumer Acceptance Department, Kimberly-Clark Corp.

Correction to Board of Directors

On page 33, August issue, Mr. Trowbridge was incorrectly identified with General Electric Co., Pittsfield, Mass. His correct identification is:

Frederick Trowbridge
Manager, Quality Control
Hallicrafters, Inc.
Chicago, Ill.

of the Pulp and Paper Industry and Canadian Pulp and Paper Association) statistics course June 19-30 at Queens College, Kingsport, Ont., Canada.

George Hall will transfer to the Delaware section this fall. He will become senior planning and controls engineer, Platex Division, International Latex Corp.

. . . TOLEDO—**Keith L. Lewis** has been appointed to the National Committee for Section Development. Nice going, Keith!

. . . WASHINGTON, D.C.—**Dr. Howard Stier,** formerly of National Canners Association, has assumed the position of QC director, United Fruit Co.

Mrs. Catherine Hock has assumed the position of vice chairman of the section since **Al McKeon** has accepted a position in Denver, Colo.

QC Courses at Indiana, Pa. State College

An eight week course in statistical quality control and a seven week course in management of quality control will be offered by State College, Indiana, Pa., during October and November.

The non-credit courses in the adult education program will meet 6:45 to 9 p.m.—the eight week course on Monday evening starting Oct. 2, and the seven week course on Friday evenings starting Oct. 6. In addition to class periods, there will be an average of three hours homework each week.

Course instructor will be Edward A. Reynolds, Quality Control Consultant, Ligonier, Pa. Both of the courses will be offered if there is sufficient demand. Interested applicants should make known their interest immediately and plan definite enrollment not later than Sept. 11.

For additional information, contact Dr. I. L. Stright of State College, Indiana, Pa.

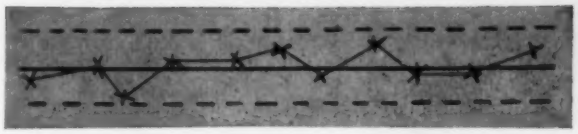
Call to Authors

16th Annual Convention
AMERICAN SOCIETY FOR QUALITY CONTROL

May 23-25, 1962

CINCINNATI, OHIO

The Convention Program Committee is soliciting contributed papers. If you are interested in presenting a paper, please send a 100 word abstract (five copies) to the Committee by Oct. 1. The complete paper ready for review by referees should be in the hands of the committee by Nov. 1. Abstracts, correspondence, and complete papers are to be sent to Michael J. O'Callaghan, chairman, Convention Program Committee, Schick Inc., Lancaster, Pa.



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SECTION CALENDAR (SEPTEMBER 1 TO OCTOBER 10)

SECTION	DATE	PLACE	TIME	SUBJECT	SPEAKER
Akron-Canton	Sept. 21	Iacominis	8:00 p.m.	Rapid Analysis of Engineering Data	Dr. Lloyd S. Nelson, Lamp Division, General Electric Co., Cleveland, Ohio William J. Masser, General Electric Co., New York, N. Y.
Allentown-Bethlehem	Sept. 13	To be announced	6:30	QC Management, Organization, Objectives and Responsibilities	.....
Chicago	Sept. 13	Teletype Corp., 5555 W. Touhy	....	Plant tour and business meeting	.....
Dayton	Sept. 14	TBA	6:30	Social evening	
Georgia	Sept. 26	Georgia Institute of Technology	....	Manufacturing Reliability and Process Capability	George Molzahn, Lockheed Aircraft Corp., Marietta, Ga.
University of Iowa	Sept. 22	Moline, Ill.	8:00	Process Control, International Harvester Night	.....
Louisville	Sept. 11	Lynn's	6:30	Odds of Living	Carl D. Larson, General Tire and Rubber Co., Logansport, Ind. William A. Golomski, Jos. Schlitz Brewing Co., Milwaukee, Wis.
	Oct. 9	Lynn's	6:30	Fundamentals of Probability	.....
Hamilton-Middletown	Sept. 13	Hamilton, Ohio	6:30	To be announced	.....
	Oct. 4	Hamilton, Ohio	6:30	Plant tour	Joseph L. Bernick, Martin Co., Baltimore, Md.
Lexington	Sept. 21	Officers' Open Mess Lexington Signal Depot	7:00	Nuclear Energy Goes to Work	
Lima	Sept. 12	Clemans Bldg.	6:30	Receiving Inspection and Vendor Relations	Frank Caplan, Jr., Westinghouse Corp., Cheswick, Pa.
	Oct. 6-7	.....	....	Intensive Course in Reliability	Harmon S. Bayer, QC Consultant, Detroit, Mich.
	Oct. 10	Clemans Bldg.	6:30	QC Personnel and Training Supervision	Edward A. Reynolds, QC Consultant, Ligonier, Pa.
Los Angeles	Sept. 28	IAS Bldg.	7:00	Quality Control at Sperry	Sperry QC Panel
Merrimack Valley	Sept. 7	Yankee Doodle Restaurant, Lawrence, Mass.	....	To be announced	.....
	Sept. 22	Lowell Technological Institute, Lowell, Mass.	....	Packaging and Packing Materials Fall Symposium	.....
Metropolitan	Sept. 9	Rutgers - The State University, New Brunswick, N. J.	9:00 a.m.	Thirteenth Annual All Day Conference	Several
Mid-Hudson	Sept. 5	Hotel DiPrima, Highland, N. Y.	7:00 p.m.	To be announced	.....
	Sept. 16	Vassar College	9:00 a.m.	One Day Seminar	Several
	Oct. 3	Hotel DiPrima, Highland, N. Y.	7:00 p.m.	To be announced	.....
Montreal	Sept. 8	Labatts Brewery	7:30	Plant tour	Fernand Loranger, Labatts Brewery, Montreal
Greater Muskegon	Sept. 14	Bill Stern's	6:30	Practical QC at National Cash Register Co.	William E. Smith, National Cash Register Co., Dayton, Ohio
Rhode Island	Sept. 21	Engineering Society Bldg., Providence, R. I.	8:00	Contractors' Responsibility to the Government for a Quality System	George Sakalaris, Providence office, INSMAT
Toledo	Sept. 7		7:30	Reducing QC Costs Through Short Cuts in Sampling	E. B. Godsey, Collins Radio Co., Cedar Rapids, Ia.
	Oct. 5	Grocery Products Division, General Mills, Inc., 1250 Laskey Rd., Toledo, Ohio	7:00	Plant tour	.....
Western Massachusetts	Sept. 26	Sheraton Motor Inn, Springfield, Mass.	2:00	One Day Quality Assurance Educational Program	R. Ramsey, Boston Ordnance District Army Base, Boston, Mass.

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Gayle McGrath — "Who Cares"
Bill McGrehan — "Total Quality Control vs. Reliability"
Ellis Ott — "Can We Export Quality Control?"
Norman Amberg — "Automated Quality Control"
Hartley Barclay (Editor of Automotive Industries) — "The 100 mph Auto with the 100,000 Mile Warranty — When?"
Harmon Bayer — "Are You a Part of the Problem or a Part of the Answer?"
Big Four Panel — Wm. Smith—Ford Motor Co.; R. C. Mortensen—AMC; E. W. Weibrecht—Chevrolet Div.; G.M.C.; E. N. Amidon—Chrysler
"Controlling Purchased Quality—How?"
A. H. Ellinwood — "Engineering & Quality Control Cooperation . . . and How To Get It"
Robert Huston (L.L.B.) — "Quality and the Labor Agreement"
J. James Miller (L.L.B.) — "Aspect of Quality in Product Liability"

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12th National Conference on Standards

Methods whereby companies may apply the philosophy and practices of standardization to reduce production costs and increase profit will be brought into sharp focus at the 12th National Conference on Standards, Oct. 10-12 in Houston, Texas.

Sponsored by the American Standards Association, the conference will afford industry the opportunity of assessing current standards work in terms of immediate and long-range goals, applications of standards in reducing costs in many areas and the financial benefits to the company from standards application. Attendance is open to all organizations and individuals, whether or not they be members of the ASA.

John R. Townsend, president, ASA, will officiate at the opening session Oct. 10. The conference keynote speaker will be Donald J. Hardenbrook, national vice-president of the National Association of Manufacturers and board chairman of the American Creosoting Corp. The welcome address will be given by the Hon. Albert Thomas, congressman from Houston's Eighth District.

In response to numerous requests from industry, the second of eight conference sessions will be devoted to a comprehensive review of standardization at all levels of the economy and in the international field.

Application of standards in the fields of plastics, material handling, safety, purchasing, data processing and mobile homes will be discussed during conference sessions Oct. 11 and 12.

The program for Oct. 11 includes morning sessions devoted to plastics, arranged by the Society of the Plastics Industry, and material handling, arranged by the American Society of Mechanical Engineers.

Two gold medals awarded annually by the ASA for outstanding support of voluntary standardization and devoted service to standardization, the Howard Coonley and Standards Medals, will be presented during an awards luncheon on Oct. 11. Guest speaker at the luncheon will be Vice Admiral W. F. Raborn, USN, chief of the Polaris program.

Afternoon sessions devoted to safety standards and application of standards in purchasing activities.

Morning sessions on data processing standards, arranged by the Office Equipment Manufacturers Institute, and the role of standards in the growth of the mobile home industry, arranged by the Mobile Homes Manufacturers Association, conclude the annual conference on Oct. 12.

Attendance at the national conference and its eight sessions is open to all companies, trade associations, technical societies, and government departments and agencies interested in standards work.

The national program chairman is H. C. Ball of Humble Oil & Refining Co. Baytown, Texas.

Information concerning the program of activities and registration blanks may be obtained from the American Standards Association, 10 East 40th Street, New York 16, N.Y.

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All information will be kept confidential and those listed will be sent descriptions of all suitable opportunities for 60 days following receipt of this initial listing. If it is your desire to remain on the list after this period, you can do so by writing to the same address and requesting an additional 60 day period. If you do *not* request an extension, you resume will be removed from the file on the assumption that you have made a successful connection.

Companies wishing to post positions available in the ASQC Personnel Listing Service should address all correspondence to the same address as above giving the educational and experience requirements, age and salary limits on each position. The position description should be limited to 100 words plus the complete name and address of the individual to whom resumes should be sent.

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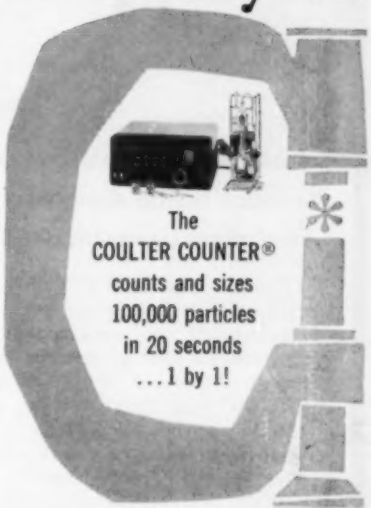

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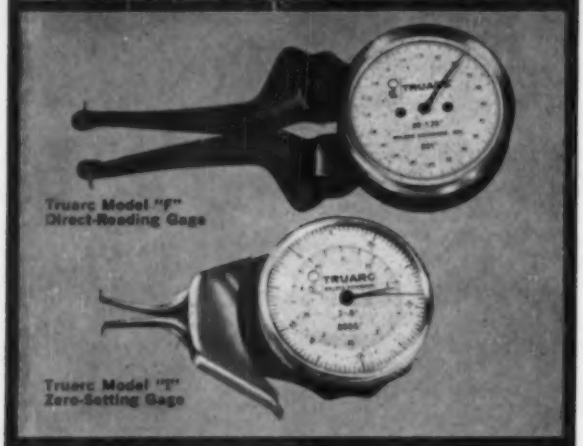

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. . . **28-Sept. 1**—International Heat Transfer Conference, Boulder, Colorado, contact American Society of Mechanical Engineers, meetings department, 29 W. 39th St., New York 18, New York.

. . . **29-Sept. 1**—66th Summer Meeting of the American Mathematical Society at Oklahoma State University, Stillwater, Okla., contact American Mathematical Society, 190 Hope St., Providence 6, R. I.

SEPTEMBER

. . . **5-15**—Statistical Methods and Advanced QC Course, Irving W. Burr, instructor, Purdue University, Lafayette, Ind., contact Statistical Laboratory, Engineering Administration Bldg., Purdue University, Lafayette, Indiana.

. . . **6-8**—Joint Nuclear Instrumentation Symposium sponsored by ISA, AIEE, and IRE, at North Carolina State College, Raleigh, N. C. Contact ISA Meetings Manager, Penn Sheraton Hotel, 530 William Penn Place, Pittsburgh 19, Pa.

. . . **9—Thirteenth Annual All Day Conference sponsored by Rutgers • The State University and the Metropolitan section, ASQC, at the Rutgers campus, New Brunswick, N. J. The program will have items of interest for all members of the quality control team and will include six concurrent sessions on applications of statistics in the ceramic, mechanical, chemical, and electronic industries plus two panels on administrative applications of statistics in the fields of auditing and accounting. "Quality Control and Statistics in Industry" includes basic and advanced topics of interest to members of the industrial, governmental and business communities. Contact Reginald Johnson, QC Manager, Eastern Surgical Dressing Plant, Johnson & Johnson, Route 1, North Brunswick, N. J.**

. . . **10-22**—Twelfth Annual Statistical Quality Control Institute, University of Connecticut, Storrs, Conn., contact Theodore A. Toedt, coordinator, University of Connecticut, Storrs, Conn.

. . . **11-15**—16th Annual ISA Instrument-Automation Conference, Biltmore Hotel, Los Angeles, Calif. Contact ISA Meetings Manager, Penn Sheraton Hotel, 530 William Penn Place, Pittsburgh 19, Pa.

. . . **12—Eighth Annual Bay Area Quality Control Conference, Stanford University, Palo Alto, Calif. Contact W. Grant Ireson, Head, Industrial Engineering Department, Stanford University, Palo Alto, Calif.**

. . . **14-15**—Ninth Annual Joint Societies Engineering Management Conference, Hotel Roosevelt, New York City. Contact IRE, 1 East 79th St., New York 21, N. Y.

. . . **15-16—ASQC-TAPPI short course in Evolutionary Operation at the Schine Inn, Chicopee, Mass. This course is being conducted in response to widespread interest in two other sessions held earlier this year. As before, the course will be given by Dr. J. Stuart Hunter, member of the Statistical Staff, University of Wisconsin, and Truman L. Koehler, head, Statistical Analysis section, American Cyanamid Co., Bound Brook, N. J. Evolutionary Operation (EVOP) is a method of operating a process in such a way as to produce on-specification product while simultaneously generating statistical information on how to improve the process (reduce costs, upgrade product quality, increase quality). Contact Miss A. Scott, TAPPI, 360 Lexington Ave., New York 17, N.Y.**

. . . **15-16**—Special two-day course in Experimental Design for Industry on Fractional Factorial Experimentation sponsored by the Extended Services Division of Rochester Institute of Technology, Rochester, N. Y. Course sessions will be held at the Country Squire Motel, Rochester, with the opening session at 8:30 a.m. on Friday, Sept. 15. Instructors will be Cuthbert Daniel and John D. Hromi. The course is specifically designed for industrial experimenters and statistical practitioners with a good understanding of the use and

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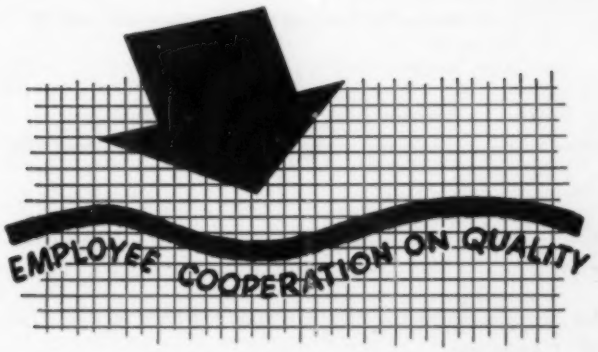

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A Consolidated Decentralized Reliability and Quality Control Program Road to Understanding Eyeball in the Milk Bottle Linear Contrasts, Part I II III Quality Control and People Statistical Quality Control—The Cybernetic Approach to Business Operations An Extended Chain Sampling Inspection Plan A Vendor Rating System for Material of Any Complexity

Instrumental Quality Control for Color Starting a Control Chart, The Effect of Number And Size of Samples on the Level of Significance at the Start of a Control Chart for Sample Means The Role of Quality Assurance in Product Reliability, Part I II A Nomogram for Upper Confidence Limits to Percent Defective Cost of Reliability A $2,000,000,000 Quality Operation

Consolidated Rating System O-C Curves for ChSP-1 Chain Sampling Plans Tolerance Limits Based on Life Test Data Taken from an Exponential Distribution Automation and Quality Control Acceptance Sampling Demonstration With a Bead Box A Graphical Method for Determining the Effect of the Isolated Factor on the Total Span in the Span Plan Analysis Build a Quality Team

A Decentralized Team Approach to Quality and Reliability The Role of Quality Control as Moderator of Applied Science in the Corporation Modern Quality Control Pays Off in Woodwork SQC vs. Intuitive Inspection The Legal Framework for Inspection Under Government Contracts Sampling Plans for Determining Compliance with Electronic Parts Reliability Requirements

Distribution of the Range and Midrange When Sampling from a Negatively Skewed, Right-Triangle Population Lot Acceptance Sampling by Variables Using the Median and Quasi- Range Conducting In-Plant Training Sessions in Statistics Applications of Industrial Statistics in Research and Development A Mixed Model Factorial Experiment in Testing Electrical Connectors

Quality Control from Front Door to Back Door Are Statistical Life-Testing Procedures Robust? Intercomparison of Laboratory Test Methods Critique of Vendor Quality Rating Systems Training for Statisticians—Industry's Need Quality Control Programs Should Be Cost Reduction Programs Quality Control in the Construction Industry A Six-Step Quality Control Program

Management Development Through Quality Control Statistical Quality Control Applications in the Food Industry Total Quality Control Through Reliability Reliability of Guided Missiles The Basic Work Elements of Quality Control Engineering Developing Quality Consciousness A New Graph for Determining CSP-1 Sampling Plans Presentation of Reliability Information

Mechanization, Quality Control, and Automation Life Test—Some Practical Considerations Selection of Flavor Panels for Complex Flavor Differences Reliability: Why is It Needed? Automatic Production Recording—Yield—And Quality Control Some Comments on the Semantics of Quality and Reliability Examples of Designed Experiments Primer on Experimentation

The Management of Reliability Programs Operationalism in Quality Control Quality in the Automotive Industry Modern Inspection Techniques and Automation Reliability Procurement Data Fun—Data Frustration—Data Failure Management Policies for Assigning Departmental Reliability Responsibilities The Experiment, the Design, the Analysis

The Brumbaugh award is presented to the author of the best article in each volume of *Industrial Quality Control*. This year the selection is being made for the articles in Volume XVII, July 1960 through June 1961. You can aid in the selection of the best article by sending your nomination now to the Brumbaugh Award Committee.

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TITLE

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AUTHOR

----------Deadline Date November 1, 1961----------

meaning of simple statistical analysis and tests of significance. Contact Extended Services Division, Rochester Institute of Technology, Rochester 8, N. Y.

. . . 16—One Day Seminar, Vassar College, 9 a.m., sponsored by the Mid-Hudson section, ASQC, contact E. L. Leadbitter, Dept. 301, Bldg. 002-3, International Business Machines, Poughkeepsie, N. Y.

. . . 16—16th Michigan Quality Control Forum, Angel Hall, University of Michigan, Ann Arbor, Mich. Contact Dale A. Cue, Hoover Ball and Bearing Co., 5400 South State Road, Ann Arbor, Mich.

. . . 16—The Scope of Quality Control, Granata Hotel, San Antonio, Texas, sponsored by the San Antonio section, ASQC, contact Robert W. Worrick, 239 E. Ackard Pl., San Antonio 21, Texas.

. . . 18-20—Tenth Annual Meeting, Standards Engineers Society, Hotel Sherman, Chicago, Ill. Theme—Standards = Cost Reduction. Contact J. E. Stevens, Chicago Bridge & Iron Co., 1305 W. 105 St., Chicago 43, Ill.

. . . 19-20—Registration for two-semester credit courses, September 1961 through May 1962, at the Carnegie Institute of Technology. Courses cover probability and mathematical statistics, experimental design, and quality control and industrial statistics, and will meet one evening a week, 7:30-10:30 p.m., Wednesday, Thursday, and Friday evenings, respectively. Registration Sept. 19-20 from 6:30-9 p.m. For further information regarding graduate and undergraduate day courses, contact Professor Edwin G. Olds, Department of Mathematics, Carnegie Institute of Technology, Pittsburgh 13, Pa.

. . . 22—Fall Symposium on Packaging and Packing Materials at Lowell Technological Institute, Lowell, Mass., sponsored by the Merrimack Valley section, ASQC. Contact Fred E. Ryan, QC Engineer, The National Co., Malden, Mass.

. . . 25-26—Fall Meeting of the Steel Founders' Society of America, the Homestead, Hot Springs, Va. Contact Chal Adams, the Bayless-Kerr Co., Hanna Bldg., Cleveland 15, Ohio.

. . . 26—One Day Quality Assurance educational program, at the Sheraton Motor Inn, Springfield, Mass., sponsored by the Western Massachusetts section, ASQC. The program is designed as a service to companies involved in government contract work who either need orientation in quality assurance requirements or have had persistent problems in fulfilling these requirements to government satisfaction. This program should be of interest not only to people concerned with government contracts, but also to those interested in introducing quality assurance into their own companies. The program will consist of five one-hour sessions beginning at 2 p.m.; dinner at 5:30 p.m., with sessions resuming at 7 p.m. and concluding at 9 p.m. Contact Alan Donnelly, Bigelow-Sanford Carpet Co., Thompsonville, Conn.

. . . 27-28—Two Day Seminar on High Energy Rate Forming at the Statler Hilton Hotel, Detroit, Mich., sponsored by the American Society of Tool and Manufacturing Engineers. The seminar will include tool design, part design, and development of high energy rate forming systems. In addition to presentation of papers, there will be two panel discussions on "HERF Tool Design" and "Establishing the Process Parameters of HERF Systems." The program will also stress the engineering properties of high energy rate worked materials and explore automation in HERF systems. Registrations must be made in advance and can be made up to the time of the seminar. Fees are $45 for ASTME members and $60 for non-members. Contact Col. Leslie S. Fletcher, Conference director, ASTME Headquarters, 10700 Puritan Ave., Detroit 38, Mich.

. . . 28-30—ASQC Chemical Division Conference, Hotel Daniel Boone, Charleston, W. Va., contact Jack L. Massau, E. I. du Pont de Nemours and Co., P. O. Box 993, Charleston 24, W. Va.

. . . 30—Western Michigan Quality Control Clinic for Business and Industry sponsored by the Greater Muskegon section, ASQC, at the Occidental Hotel. Contact Merrill S. Bailey, Anaconda Wire and Cable Co., Muskegon, Mich.

OCTOBER

. . . 2—Community College Courses in Industrial Quality Control, an adult education, noncredit program offered by State College, Indiana, Pa. An eight week course in statistical quality control will start Oct. 2. A seven week course in management of quality control will start Oct. 6. The courses will meet one night a week from 6:45 to 9 p.m. Instructor—Edward A. Reynolds, Quality Control Consultant, Ligonier, Pa. Contact Dr. I. L. Stright, State College, Indiana, Pa. Plan definite enrollment not later than Sept. 11.

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. . . 4-6—Semi-Annual Convention, American Society of Photogrammetry, Biltmore Hotel, New York City. Contact Timothy Trott, Aeroflex Corp., 34-06 Skillman Ave., Long Island City, N. Y.

. . . 6-7—Intensive Short Course in Reliability sponsored by the Lima section, ASQC. Harmon S. Bayer, Quality Control Consultant, Detroit, Mich., will be the instructor. Contact D. C. Fultz, Lima Engine Plant, Ford Motor Co., Lima, Ohio.

. . . 10-12—12th National Conference on Standards, Rice Hotel, Houston, Texas. Contact American Standards Association, 10 E. 40th St., New York 16, N. Y.

. . . 12-14—Three day short course on the Evaluation and Interpretation of Physical and Chemical Testing Methods at the Red Lobster Restaurant-Kenton Manor Motel, Tonawanda, New York. It will be sponsored by the Chemical Division, ASQC, and the Buffalo section, ASQC. Course instructors will be John Mandel, a member of the Testing and Specifications section at the National Bureau of Standards, and Grant Wernimont, Eastman Kodak Co., a pioneer in the study of accuracy and precision of testing methods. The course will be of value to laboratory personnel of all industries who have little or no experience in the statistical treatment of test data and evaluation of test methods. No experience in statistics is required. Contact James E. Dillman, chairman, Chemical Division Lab Course, Hooker Chemical Corp., P. O. Box 344, Niagara Falls, N. Y.

. . . 15-19—17th International Instrument-Automation Conference, Coliseum, New York City. Contact Instrument Society of America, 313 Sixth Ave., Pittsburgh 22, Pa.

. . . 19-20—16th Midwest Quality Control Conference, Chase-Park Plaza Hotel, St. Louis, Mo. The theme—The University of Statistics—will be carried out by talks on statistics and baseball, statistics and sex, statistics and stock market, statistics and gambling, statistics and crime, statistics and medicine, statistics and warfare, and statistics and weather. The conference will also include papers on basic and advanced QC techniques and will feature basic, advanced, and section management training courses. Contact H. H. Bock, registration chairman, Olin-Mathieson Chemical Corp., East Alton, Ill.

. . . 24-25—Product Maintainability Working Seminar, Sheraton Hotel, Philadelphia, Pa., sponsored by the Electronics Division, ASQC. Contact B. W. Marguglio, Martin Co., Mail No. 2000, Baltimore 3, Md.

. . . 25-27—15th New England Quality Control Conference, Statler Hilton Hotel, Hartford, Conn. Contact the registration chairman—John A. Sigmann, R. T. Vanderbilt Co., Inc., East Norwalk, Conn.

. . . 26-27—Two-day Training Program, University of Chicago, downtown campus, Chicago, Ill., contact Burton Persky, Teletype Corp., 5555 W. Touhy Ave., Skokie, Ill., Telephone OR 6-1000, Ext. 575.

. . . 26-27—Annual Quality Control Conference, University of Alabama, Tuscaloosa, Ala. Contact E. T. Finnell, Jr., Engineering Extension Services, University of Alabama, Tuscaloosa, Ala.

. . . 28—All Day Quality Control Forum at Ecole Polytechnique sponsored by the Montreal section, ASQC. Contact Denys A. Pilon, Quality Control Chemist, Canada Packers Ltd., 1260 Mill Street, Montreal, Quebec, Canada.

NOVEMBER

. . . 9-10—Eleventh Annual Conference of the Aircraft and Missile Division, ASQC, Ambassador Hotel, Los Angeles, Calif., theme—Assuring Customer Satisfaction, four concurrent series of sessions on international and general interest, design—reliability, production—quality control, and field service—maintainability. Contact Hardy Harris, publicity chairman, c/o North American Aviation, Inc., International Airport, Los Angeles 45, Calif.

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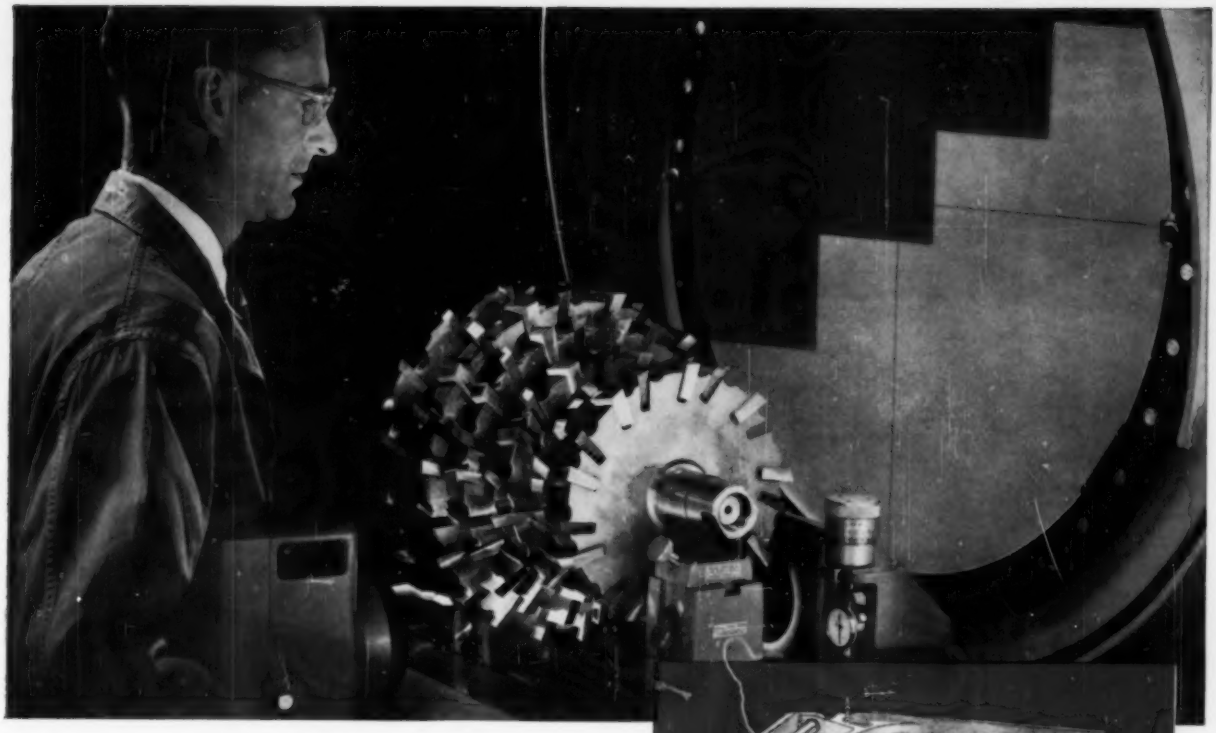

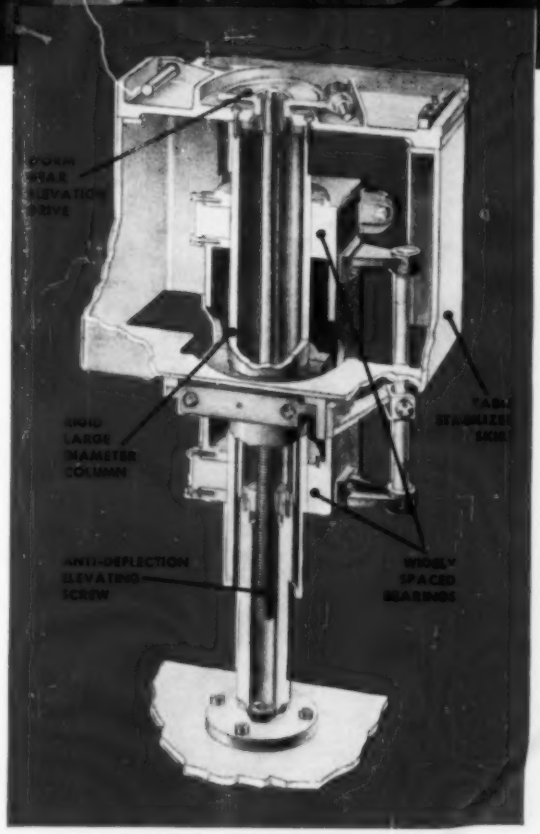

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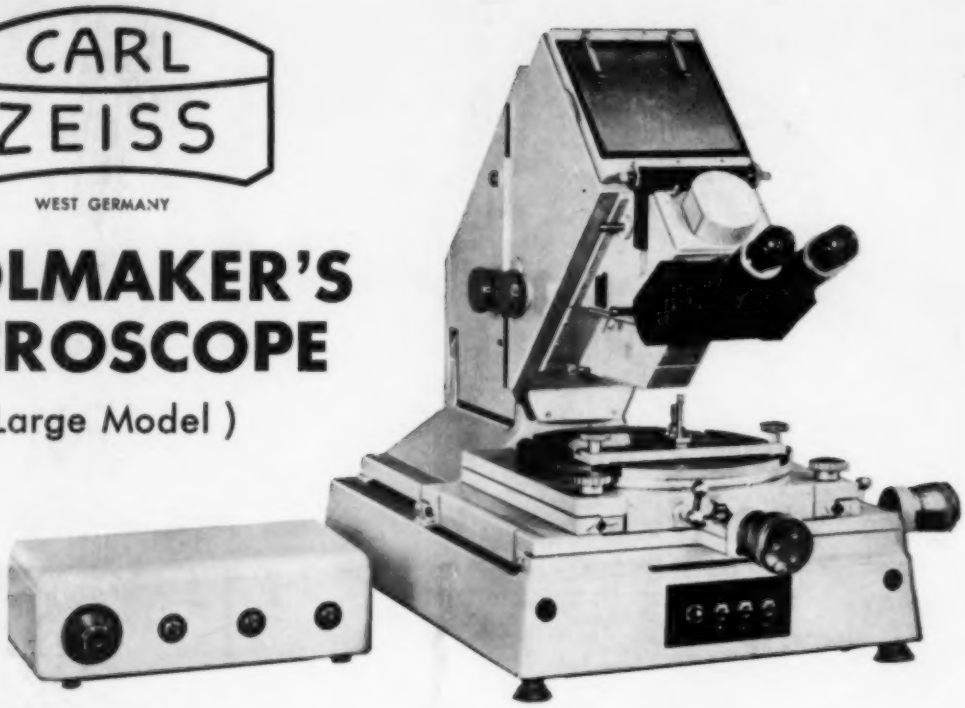

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